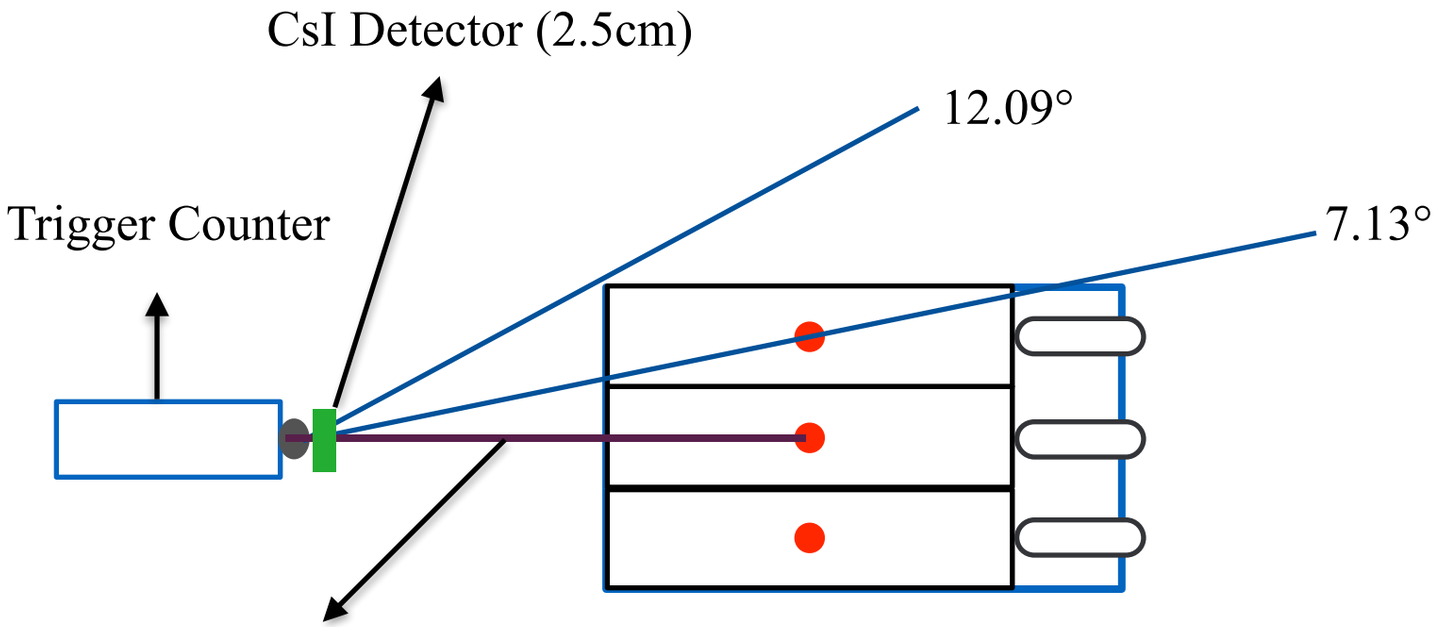
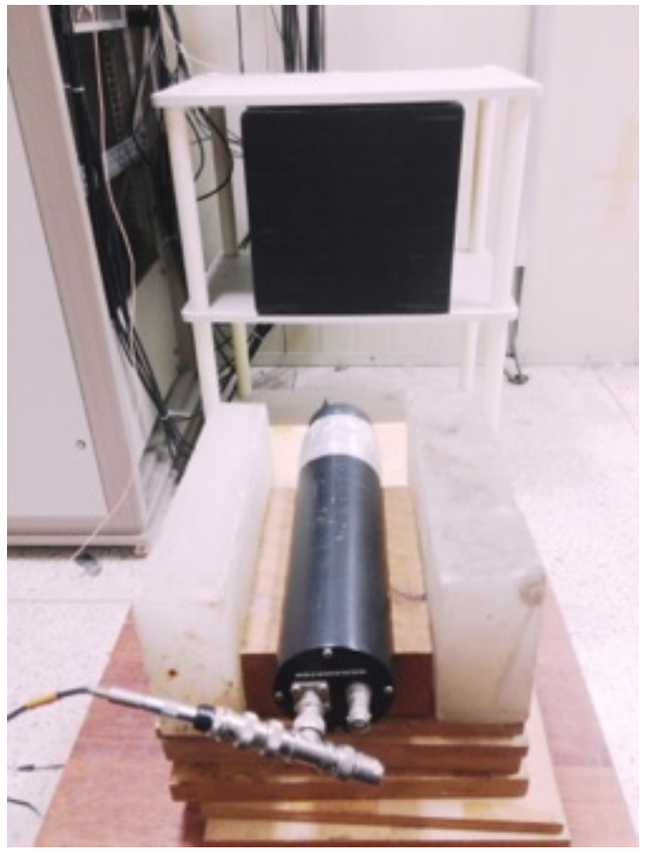
LAMPS-Low Neutron Detector Test

Jae Beom Park

LAMPS –low Neutron Detector Experimental Setup

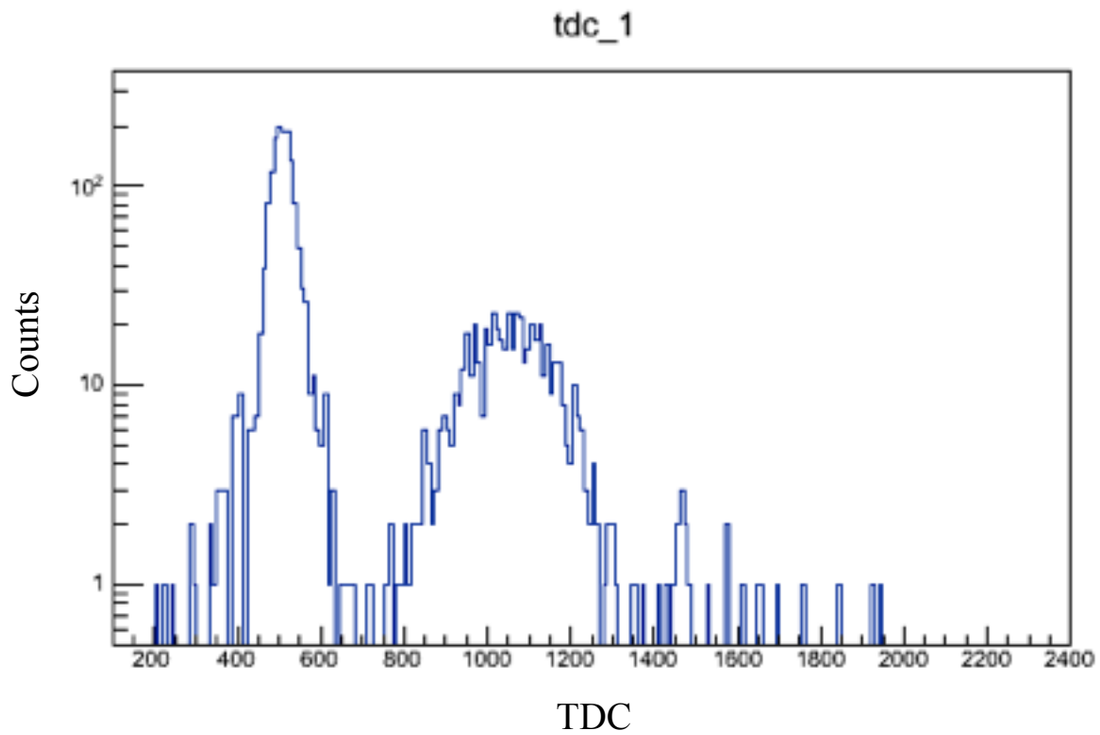


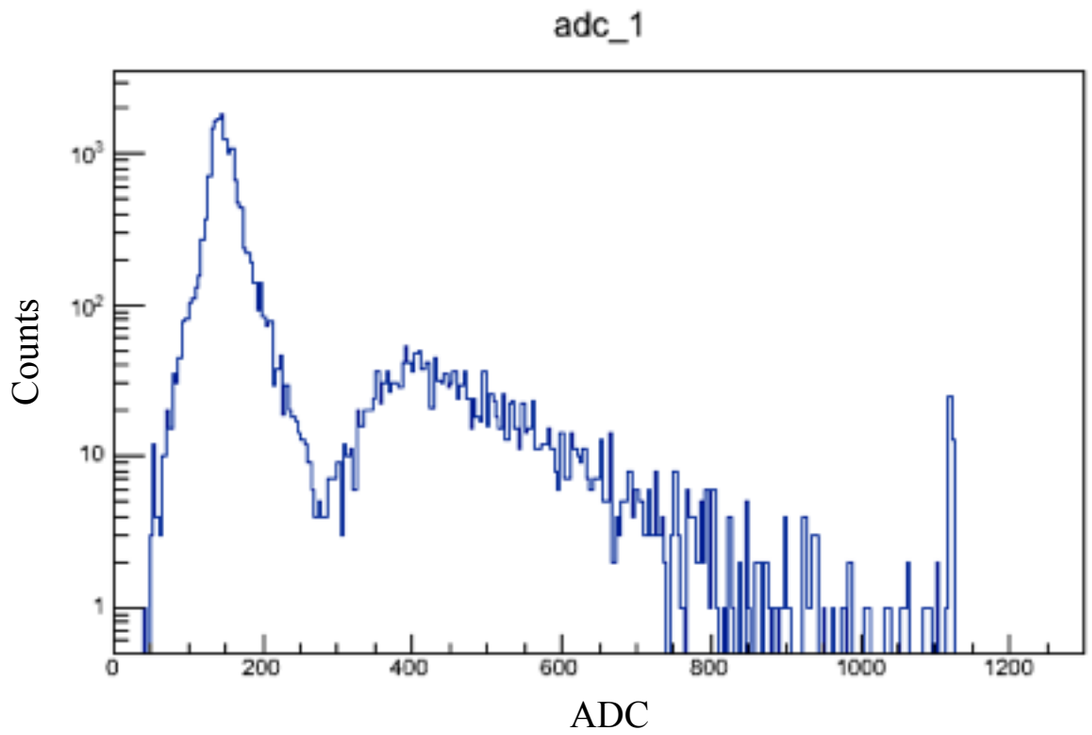
[Side View]



[Front View]

LAMPS –low Neutron Detector raw data for one module

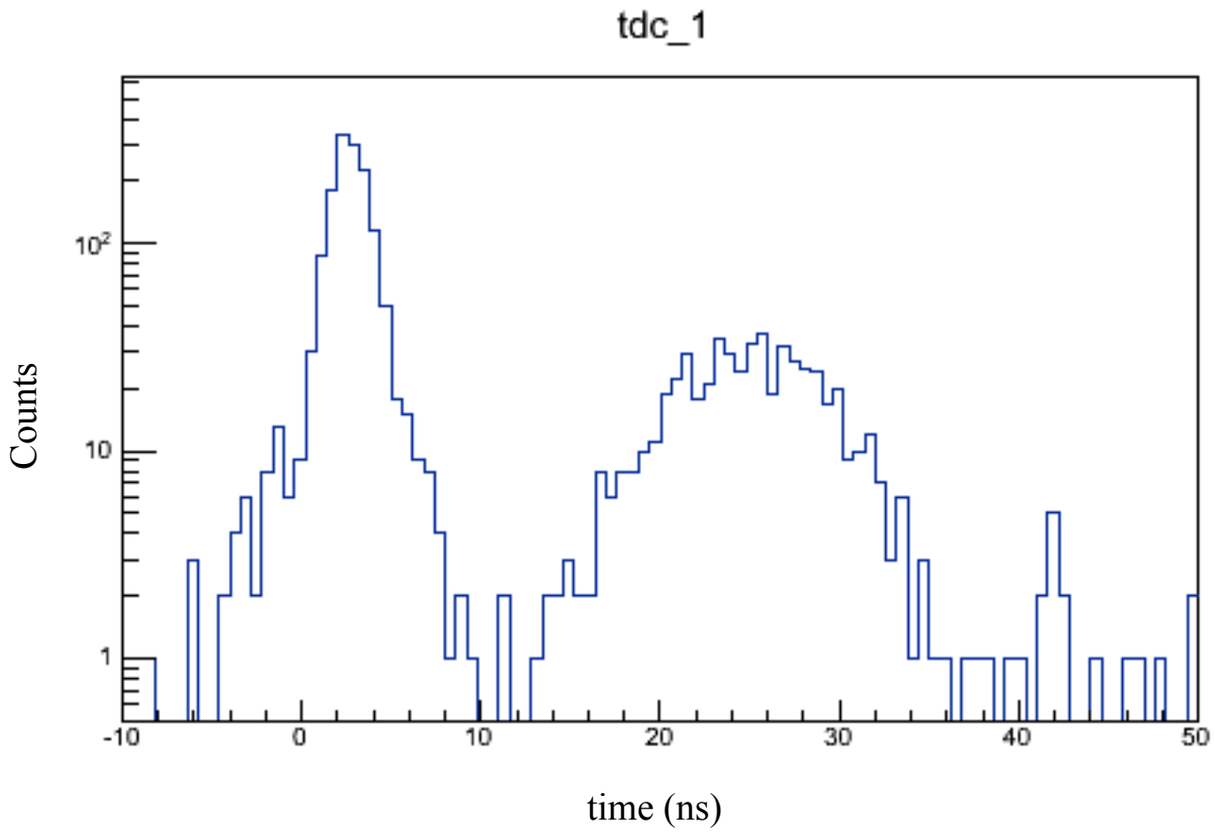


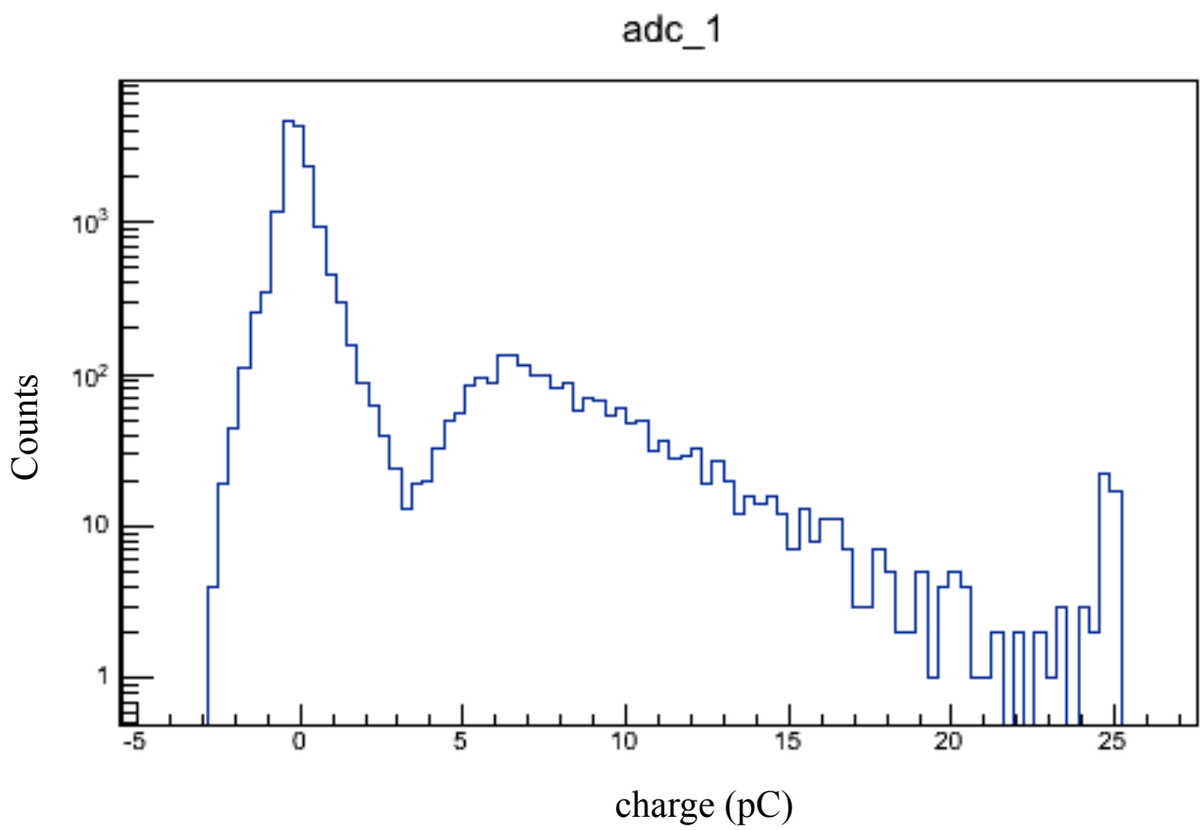


LAMPS –low Neutron Detector Data Analysis Plan

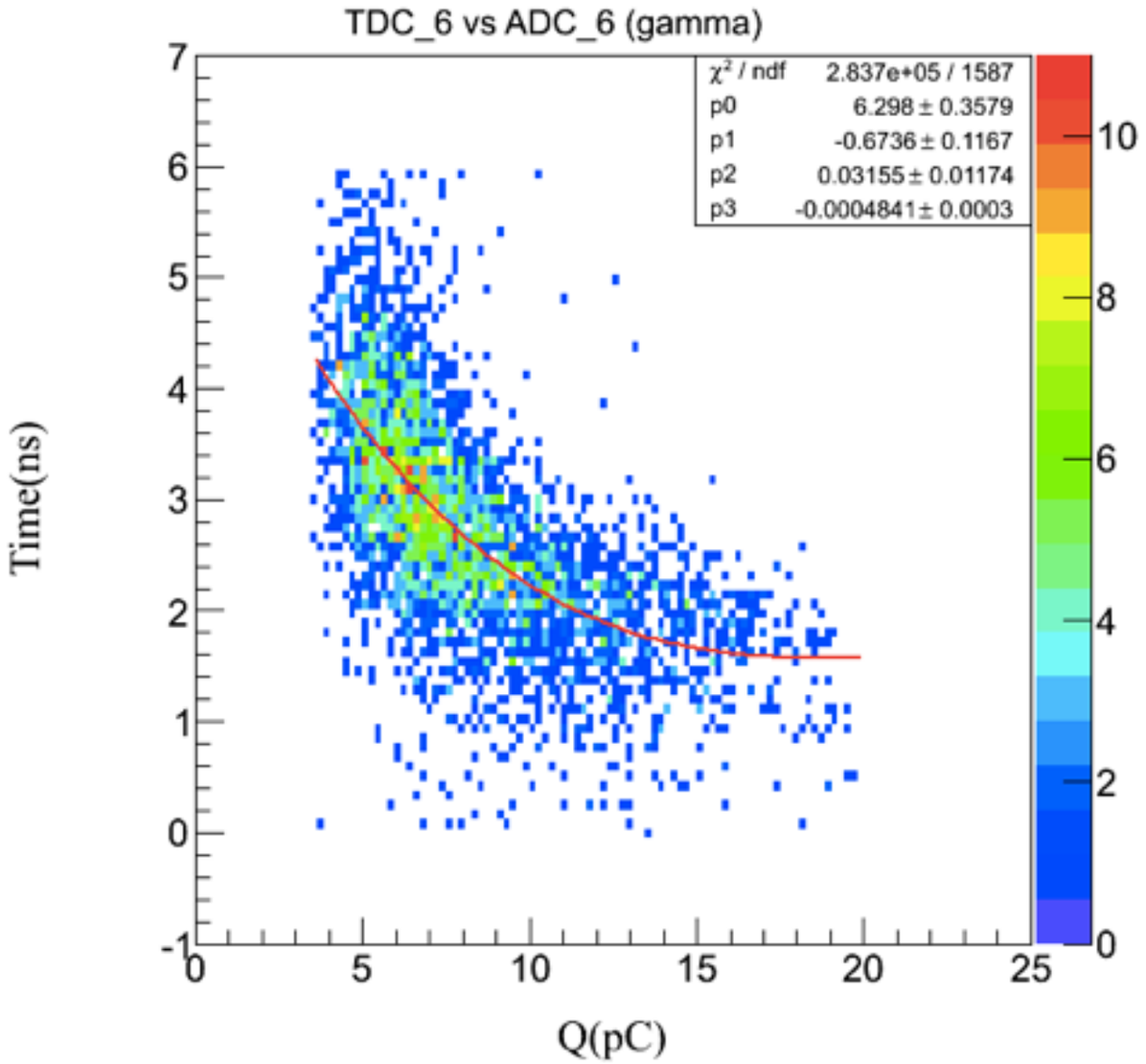
1. TDC time scaling & ADC pedestal subtraction
2. Setting TDC time offset
3. Time Walk Correction using gammas
4. Hit clusterization
5. Noise filtering

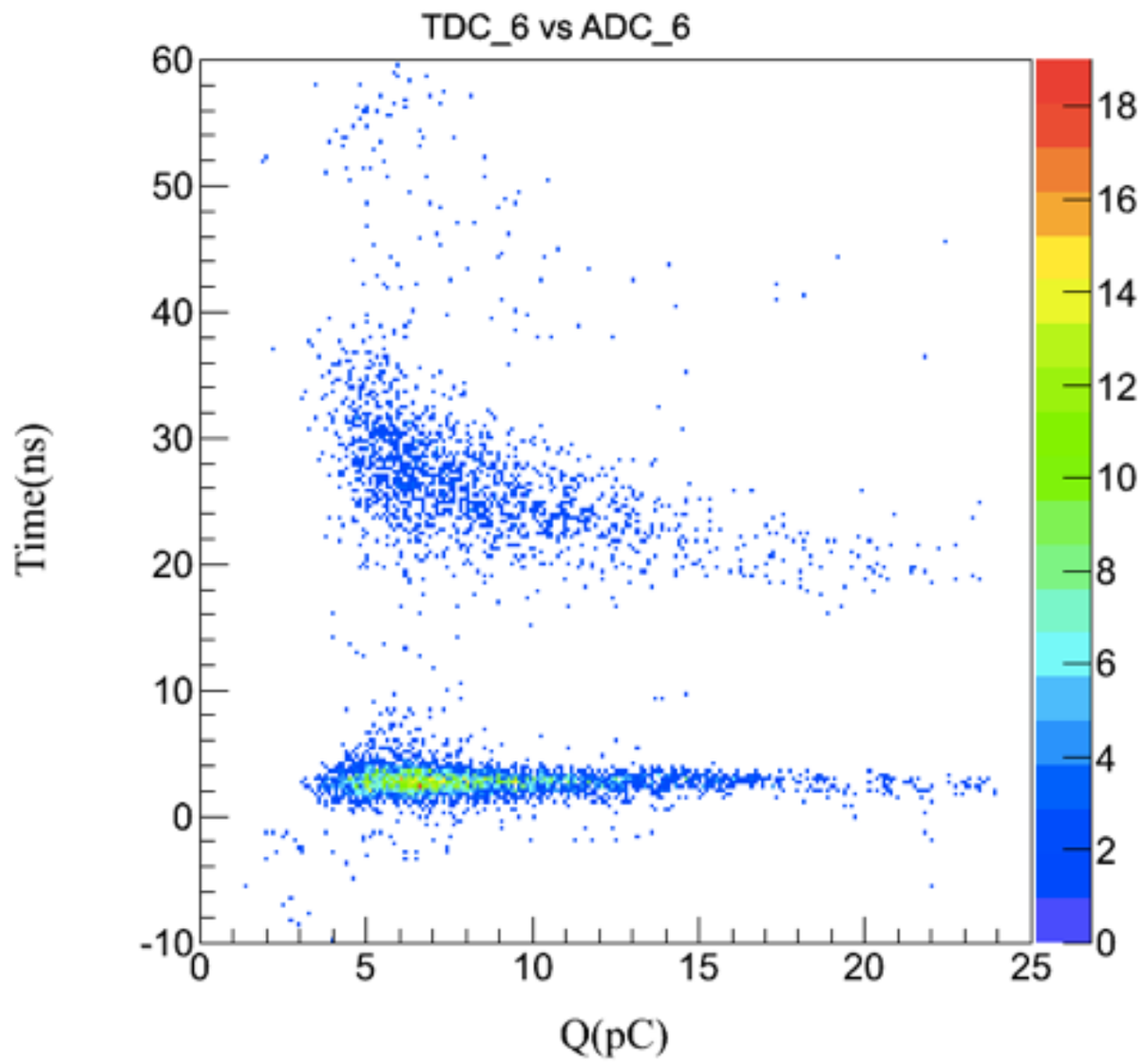
LAMPS –low Neutron Detector Data



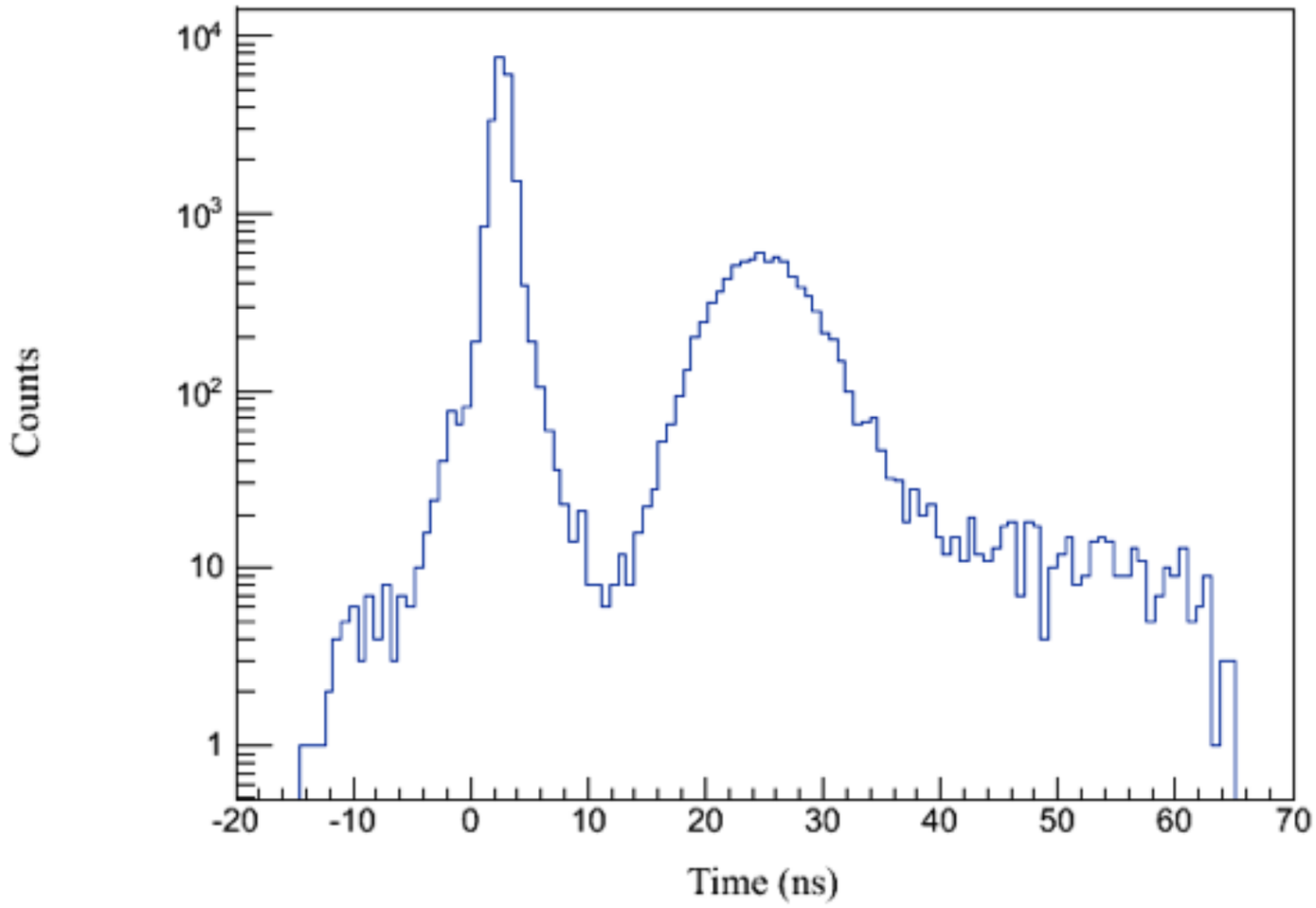


Slewing Correction

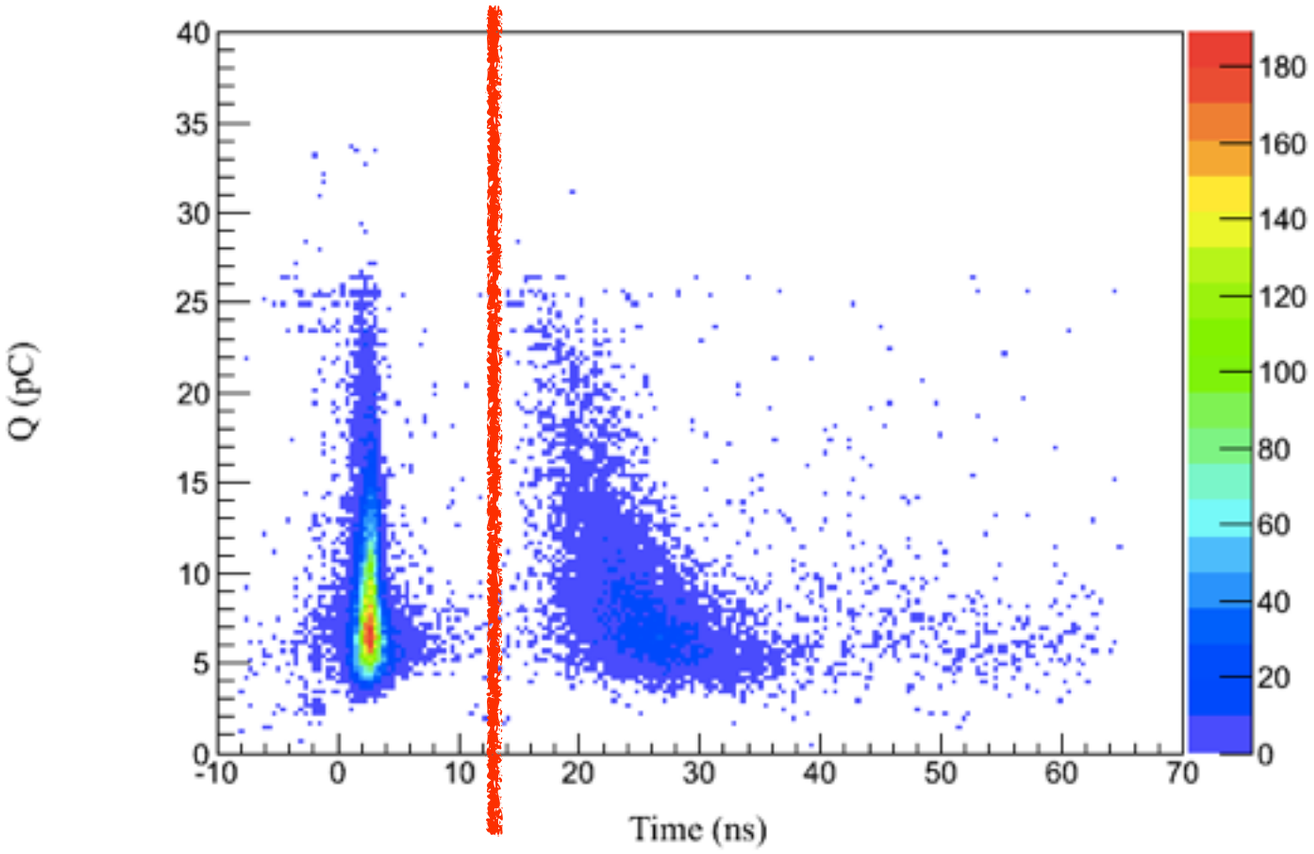




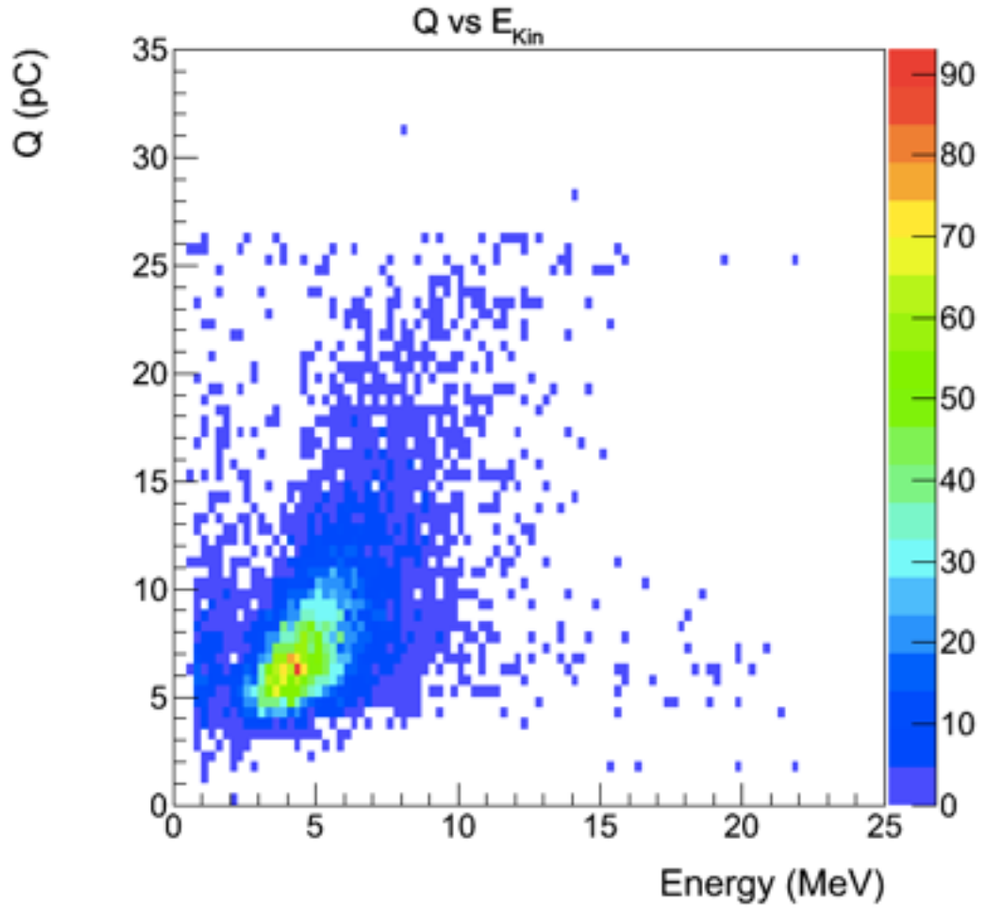
ToF of 252Cf Source



Neutron Seperation

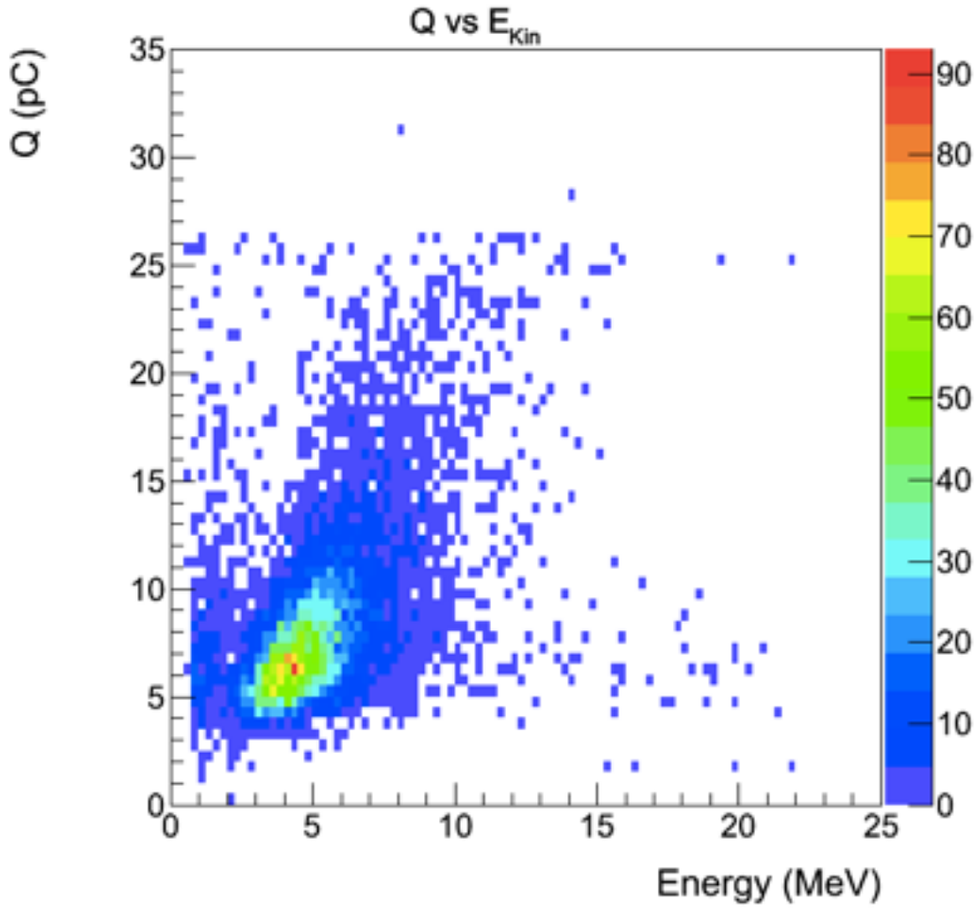


Gamma+Neutron+Accidental

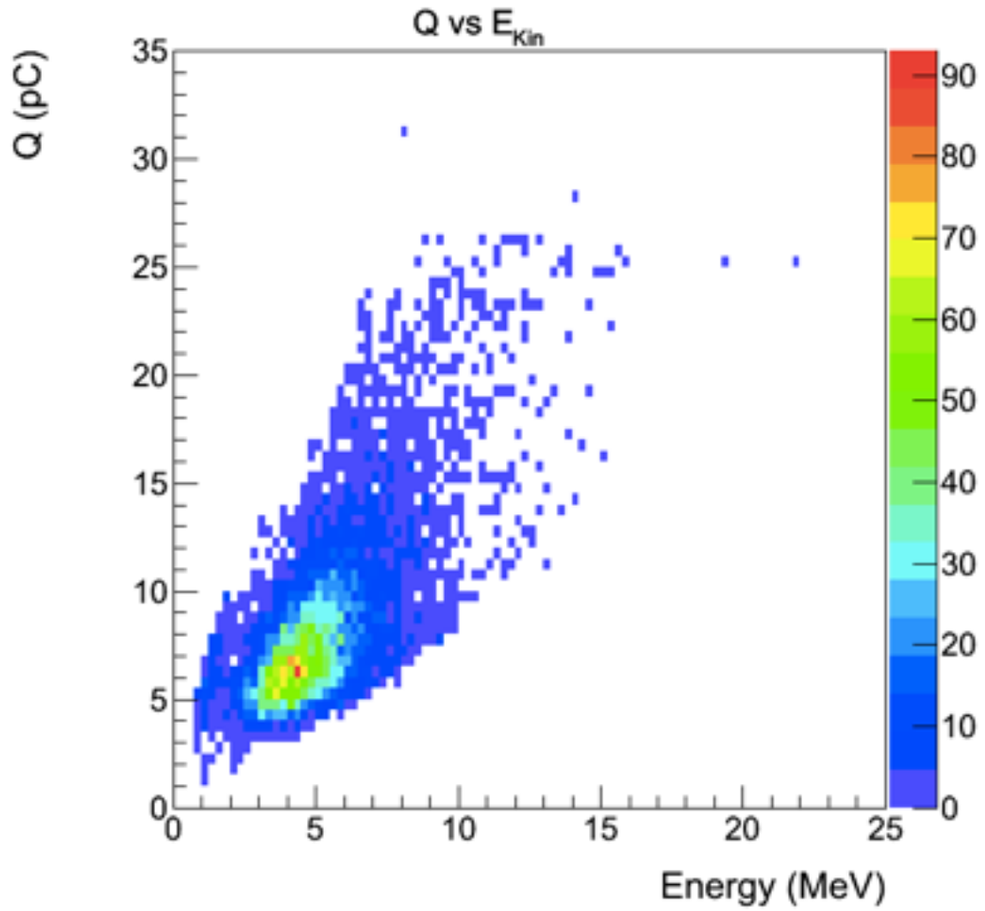


Neutron + Accidental

Neutron Separation

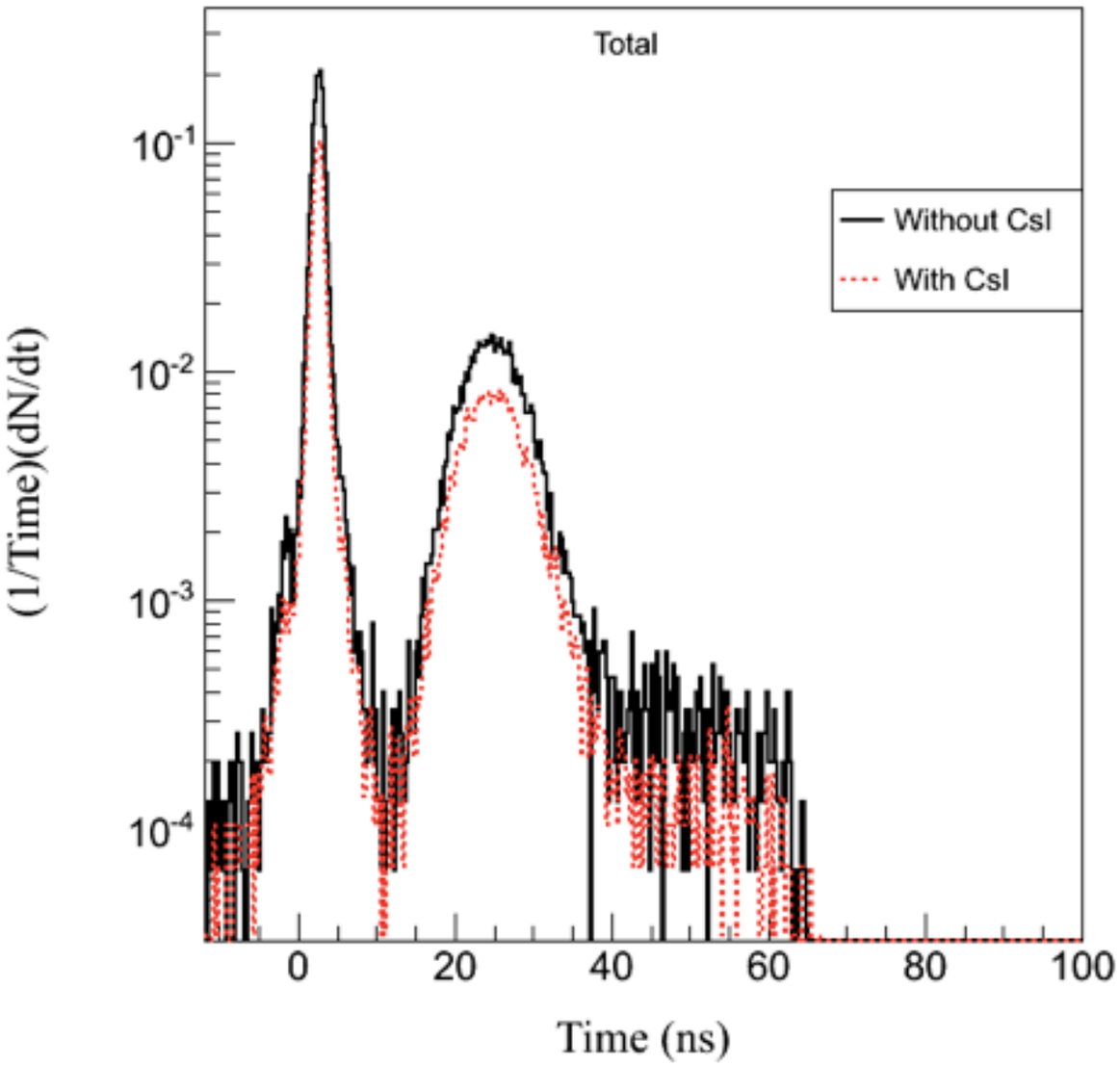


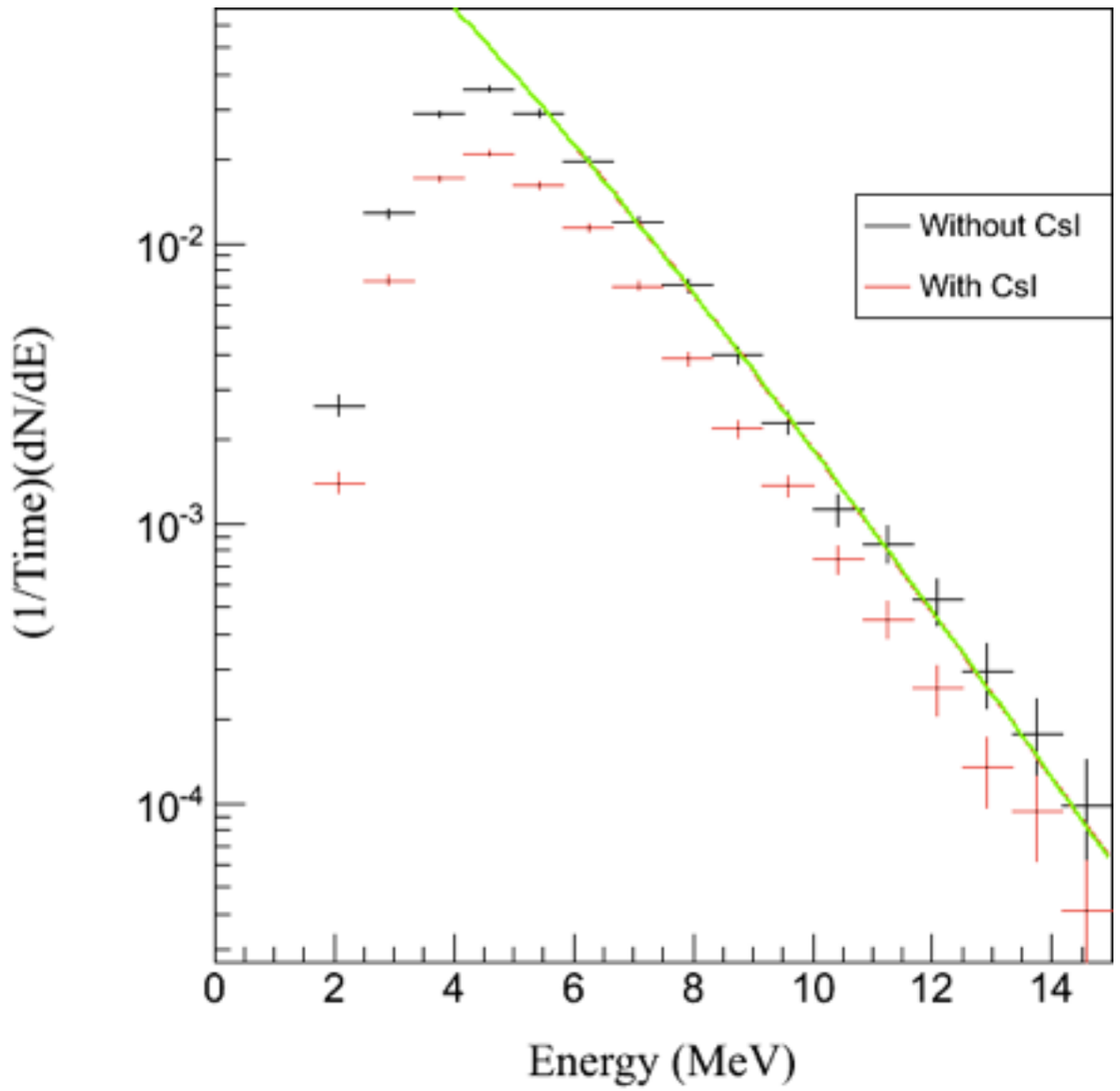
Neutron + Accidental



Neutron

Result with CsI





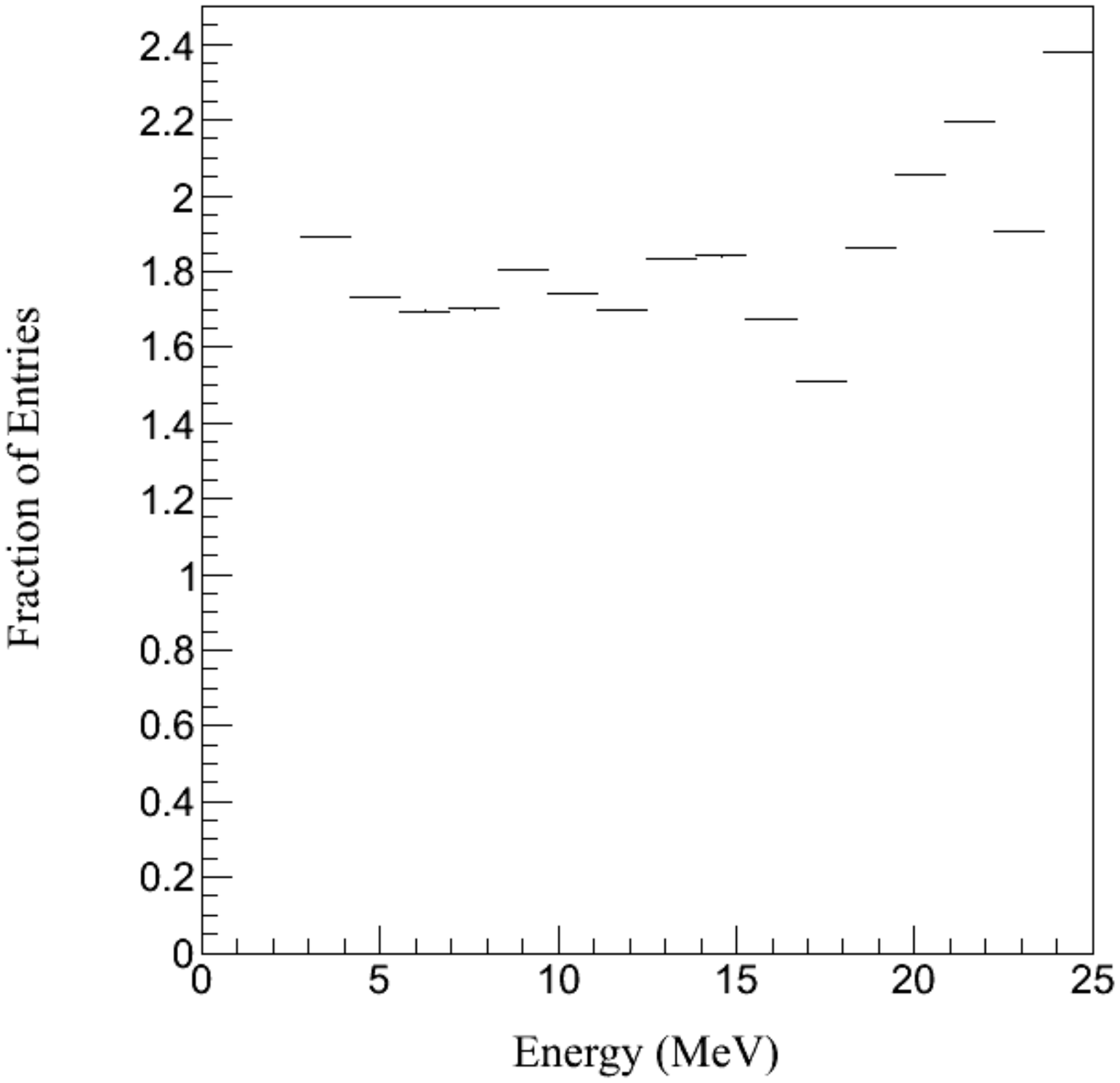
Loss of the effect CsI

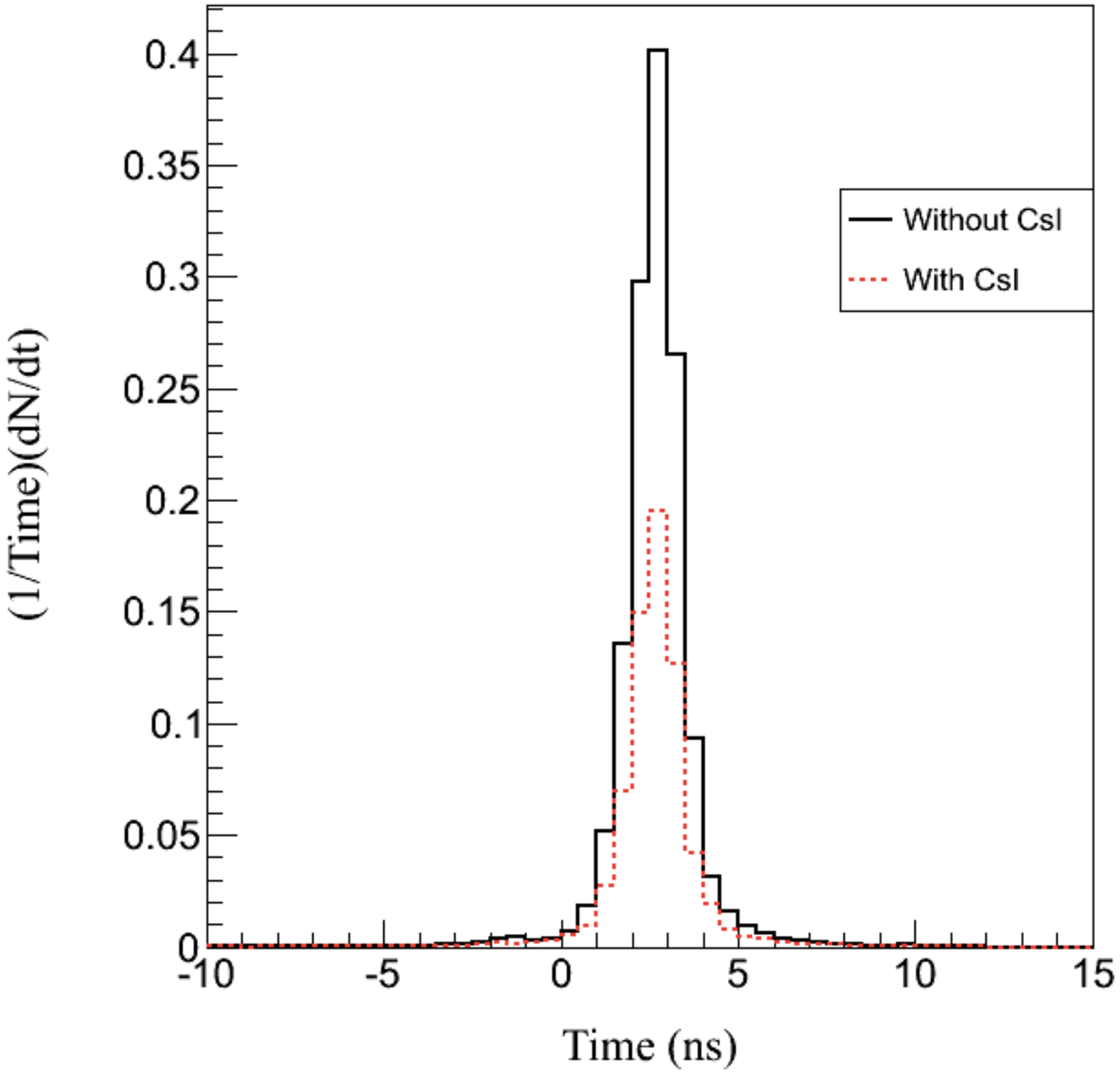
	Without CsI	With CsI	Loss of particles by normalizing in time
Run Time (s)	60960	116100	
# of total particles	30,000	30,000	
# of gammas per time	0.33807	0.16812	50.27 (%)
# of Neutrons per time	0.13440	0.07677	42.86 (%)

Plan

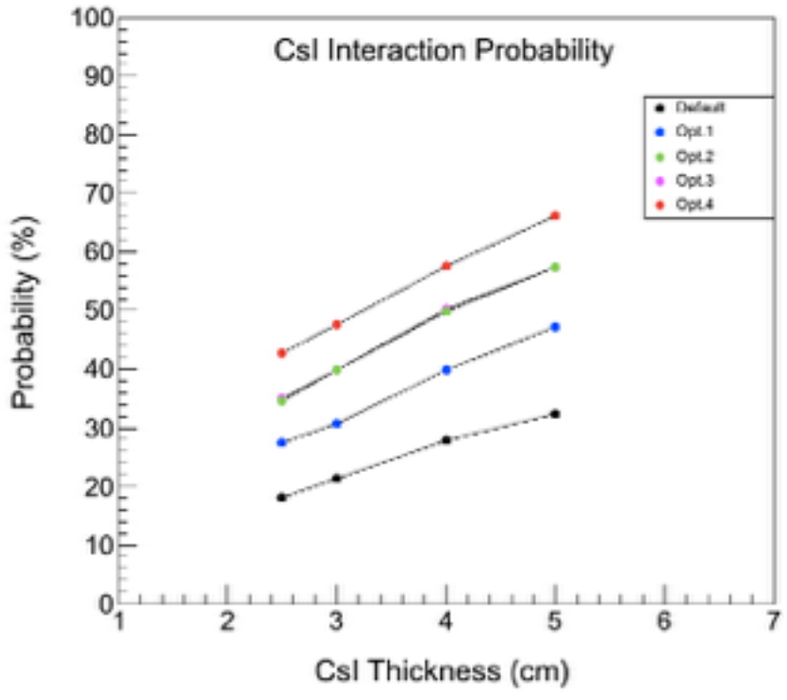
1. Neutron Detector Test with CsI (5cm) readout in Prof. Ahn Lab
2. Test using FADC in KU & KIRAMS (15/02/09)

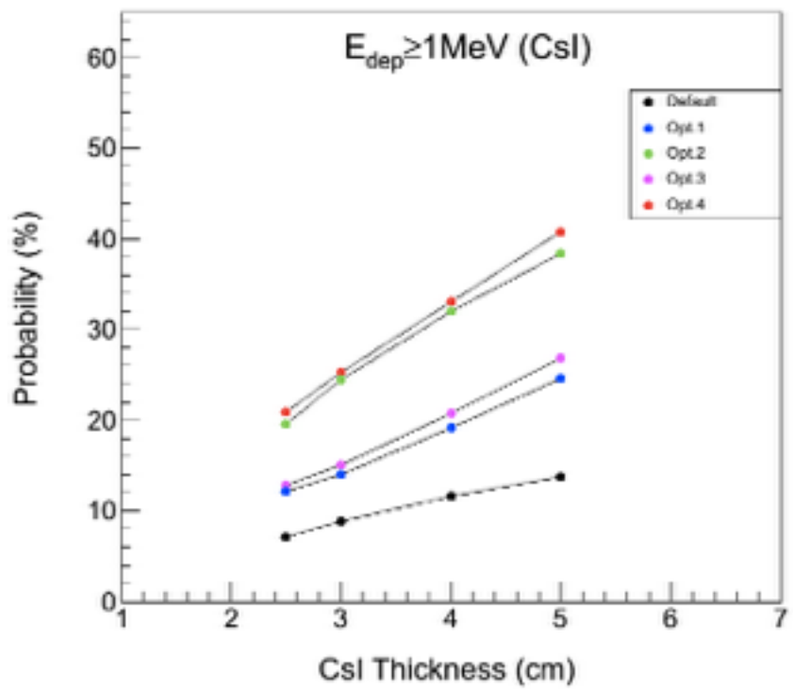
Back-up

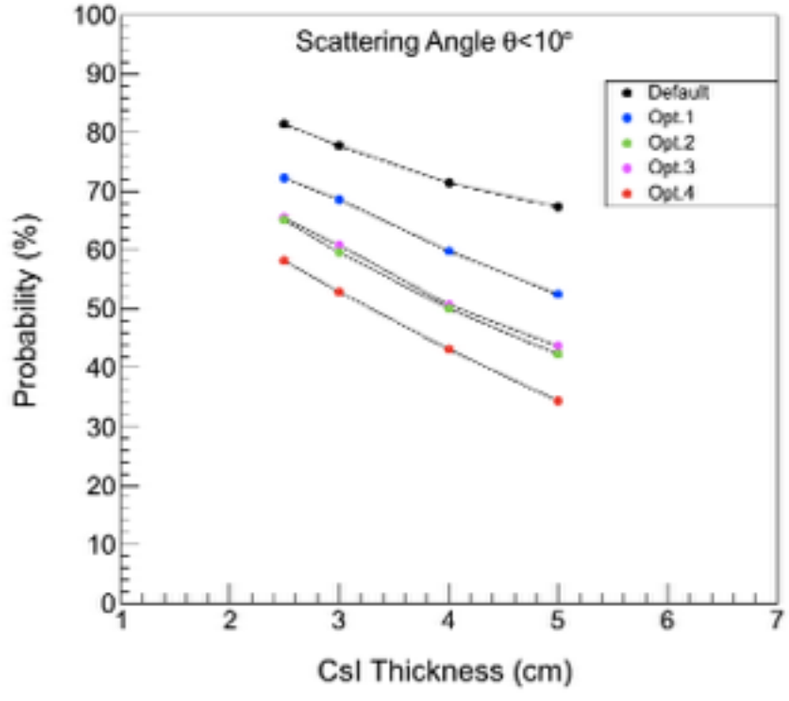

Fraction of Entries
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
5
10
15
20
25
Energy (MeV)


0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
-10
-5
0
5
10
15
(1/Time)(dN/dt)
Time (ns)
Without CsI
With CsI

Summary of the Si-CsI effect

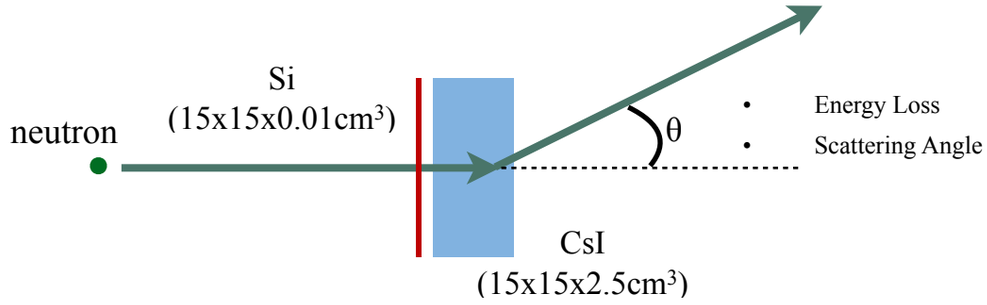


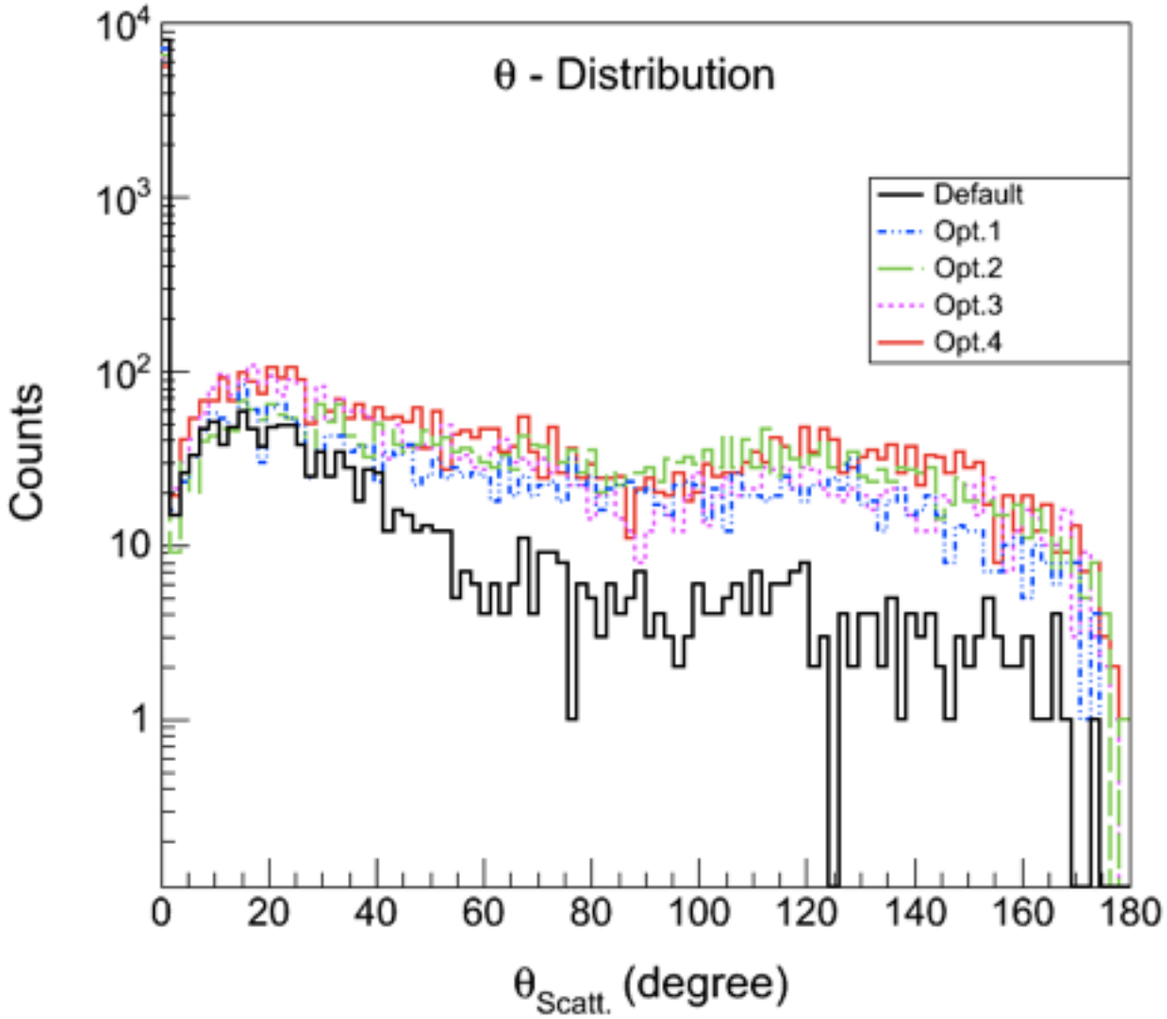


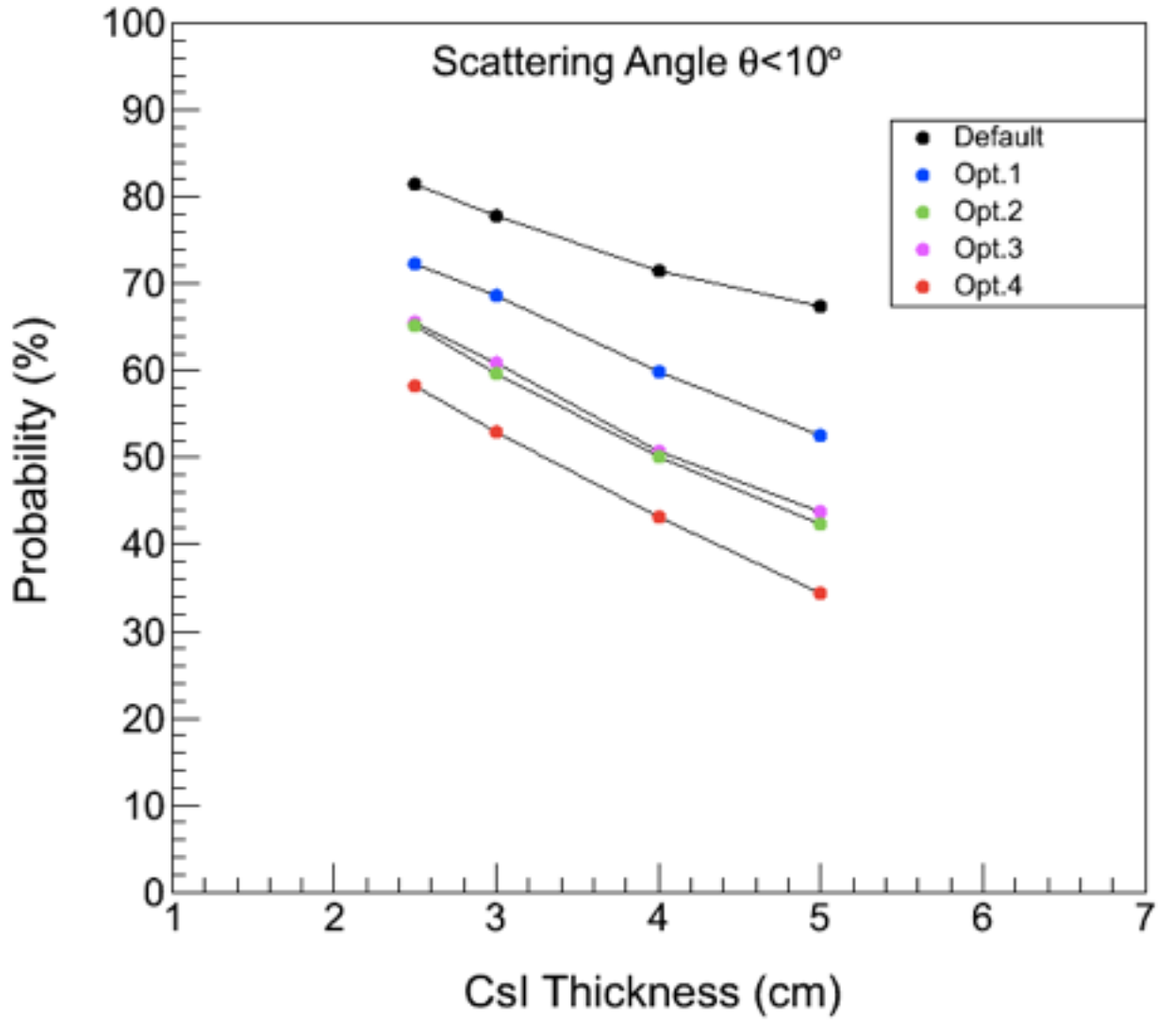


Effect of Si-CsI Detector

Beam Energy = 10 MeV
Depth of CsI = 2.5cm
# of Events = 10,000

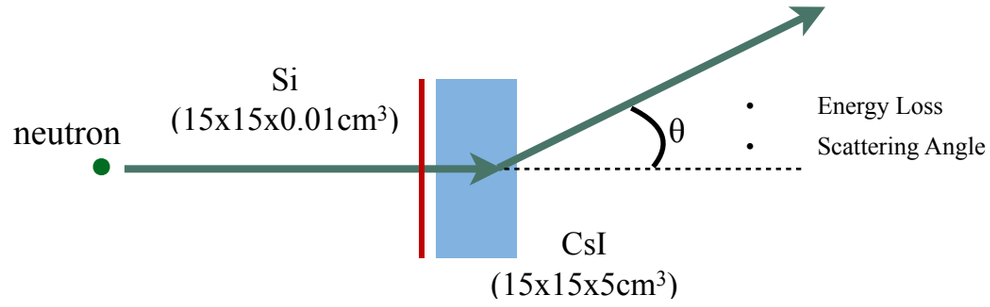


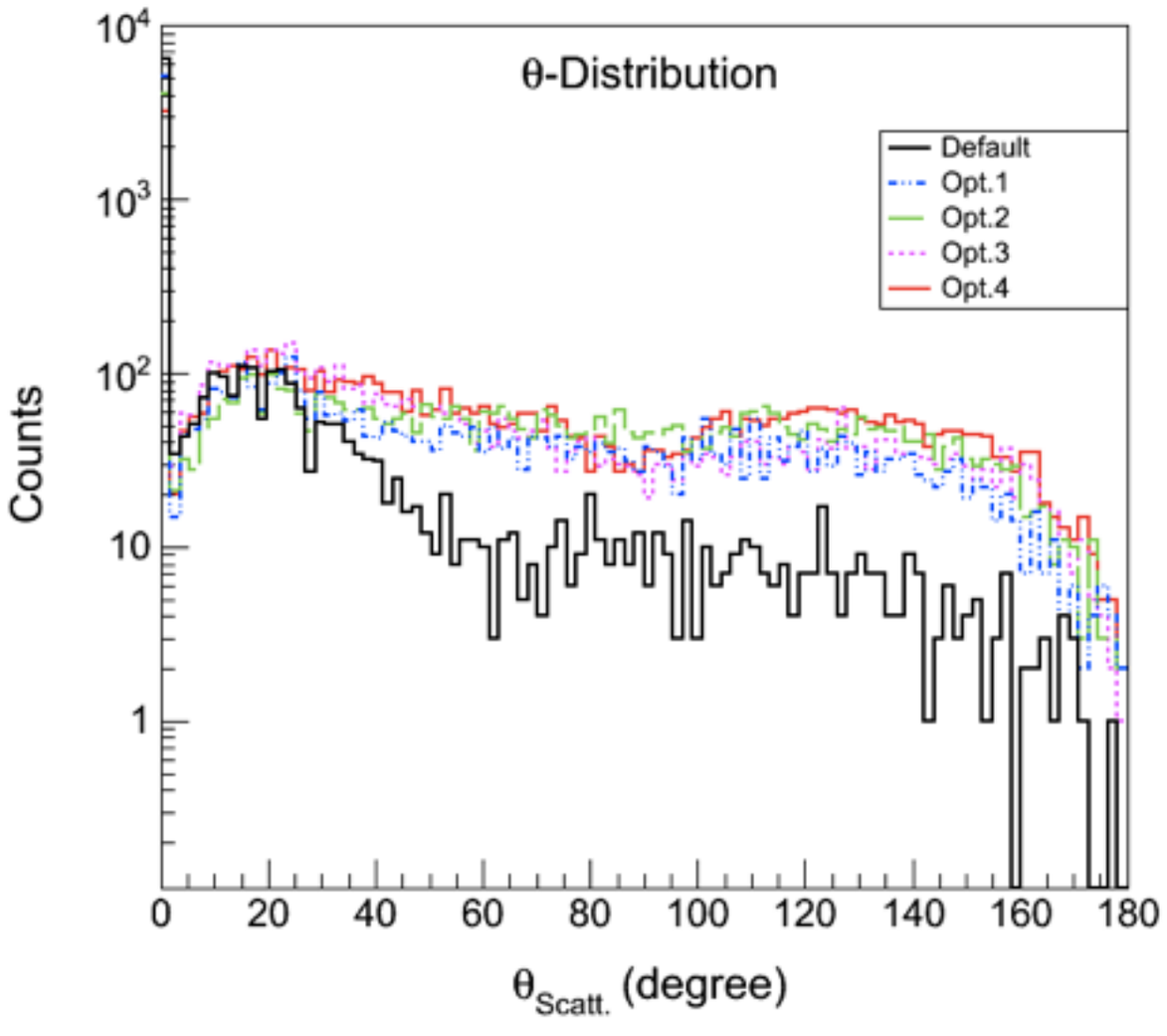


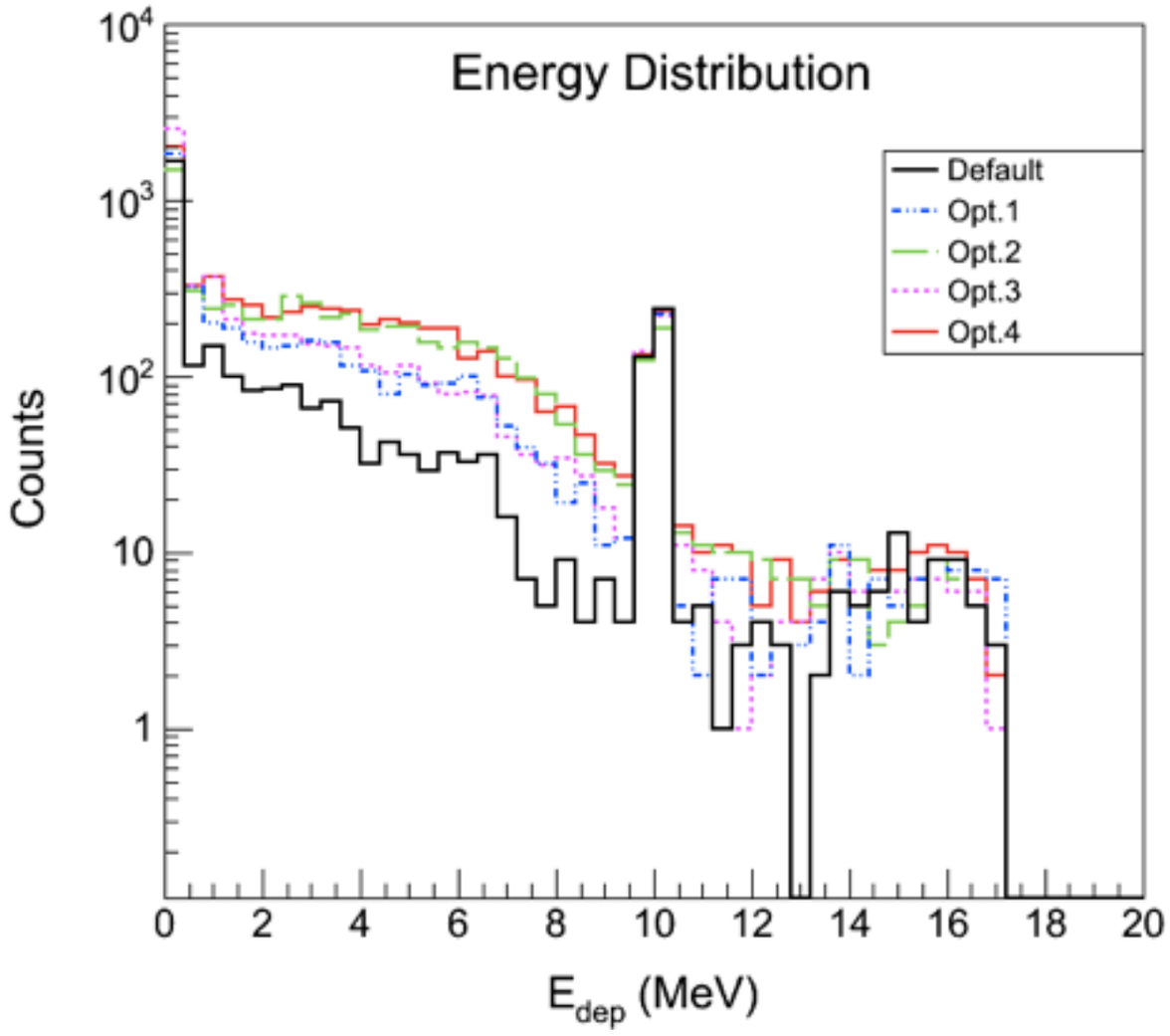


Effect of Si-CsI Detector

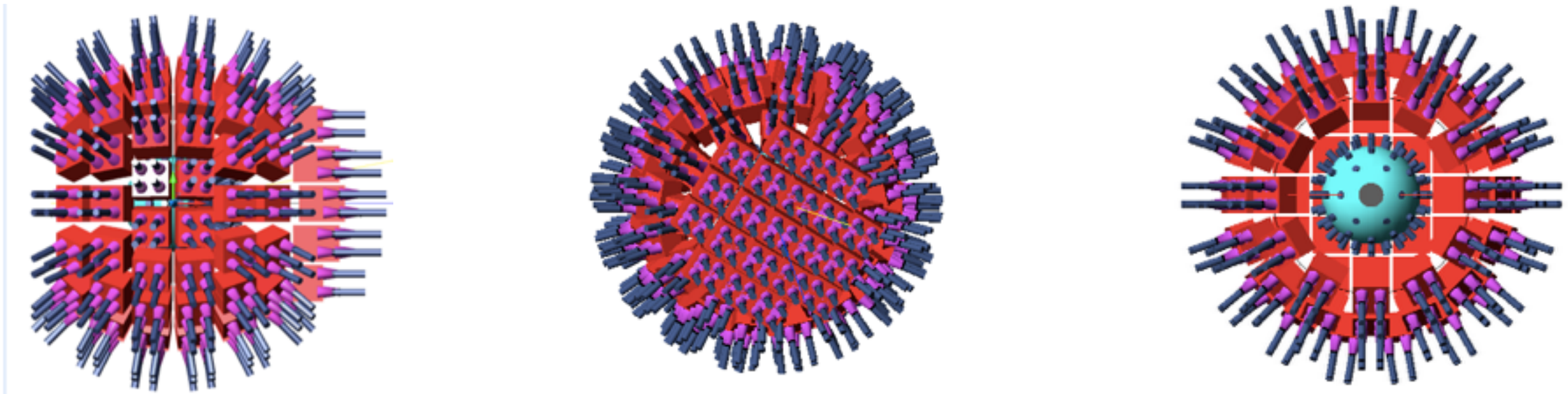
Beam Energy = 10 MeV
Depth of CsI = 5cm
# of Events = 10,000







Full Geometry



1 super module = 4 unit detector

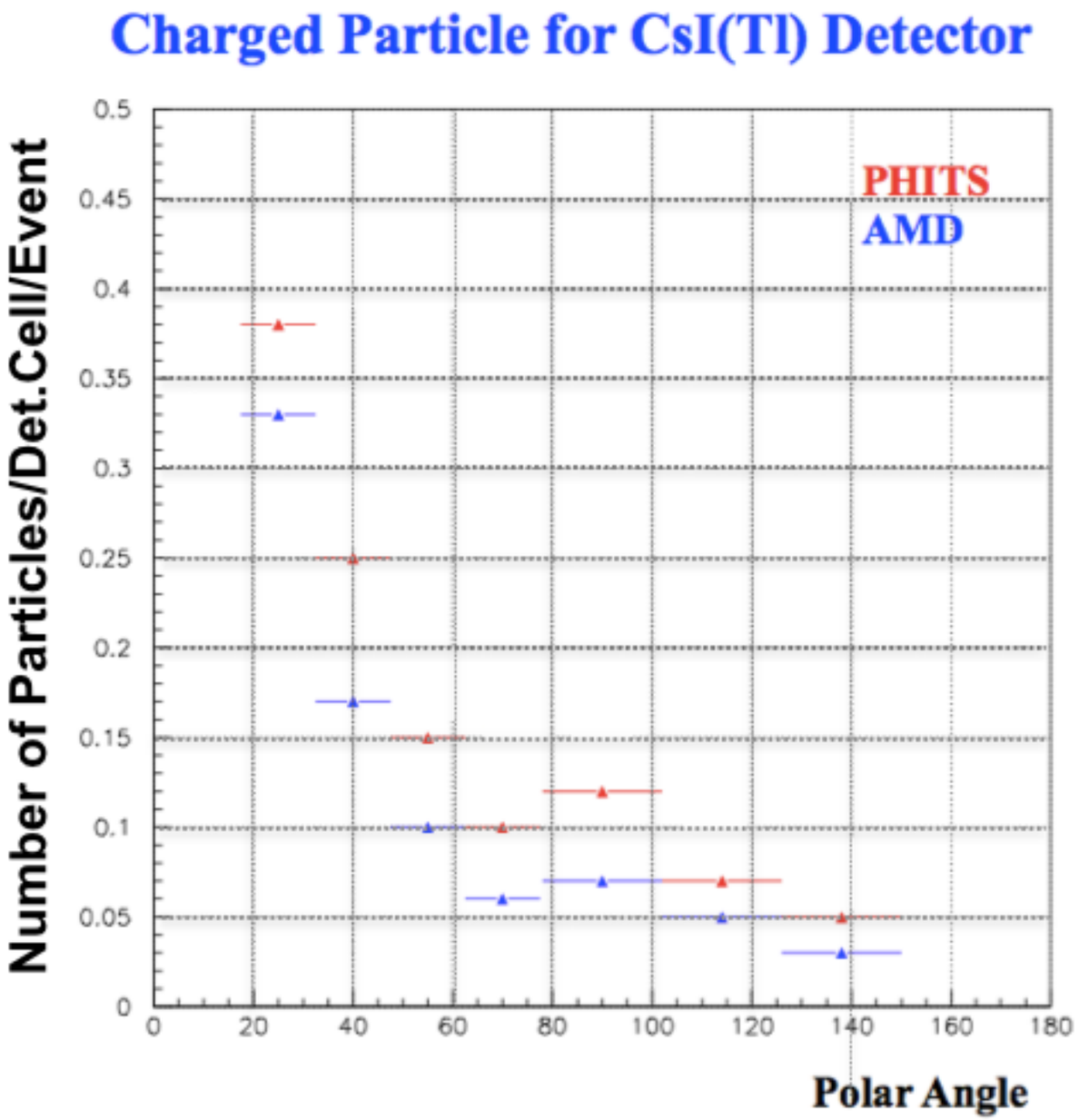
Forward Detector Wall : Cover Range 0 ~ 36 degree, ToF Dist. : 1.3m
# of unit detector 84

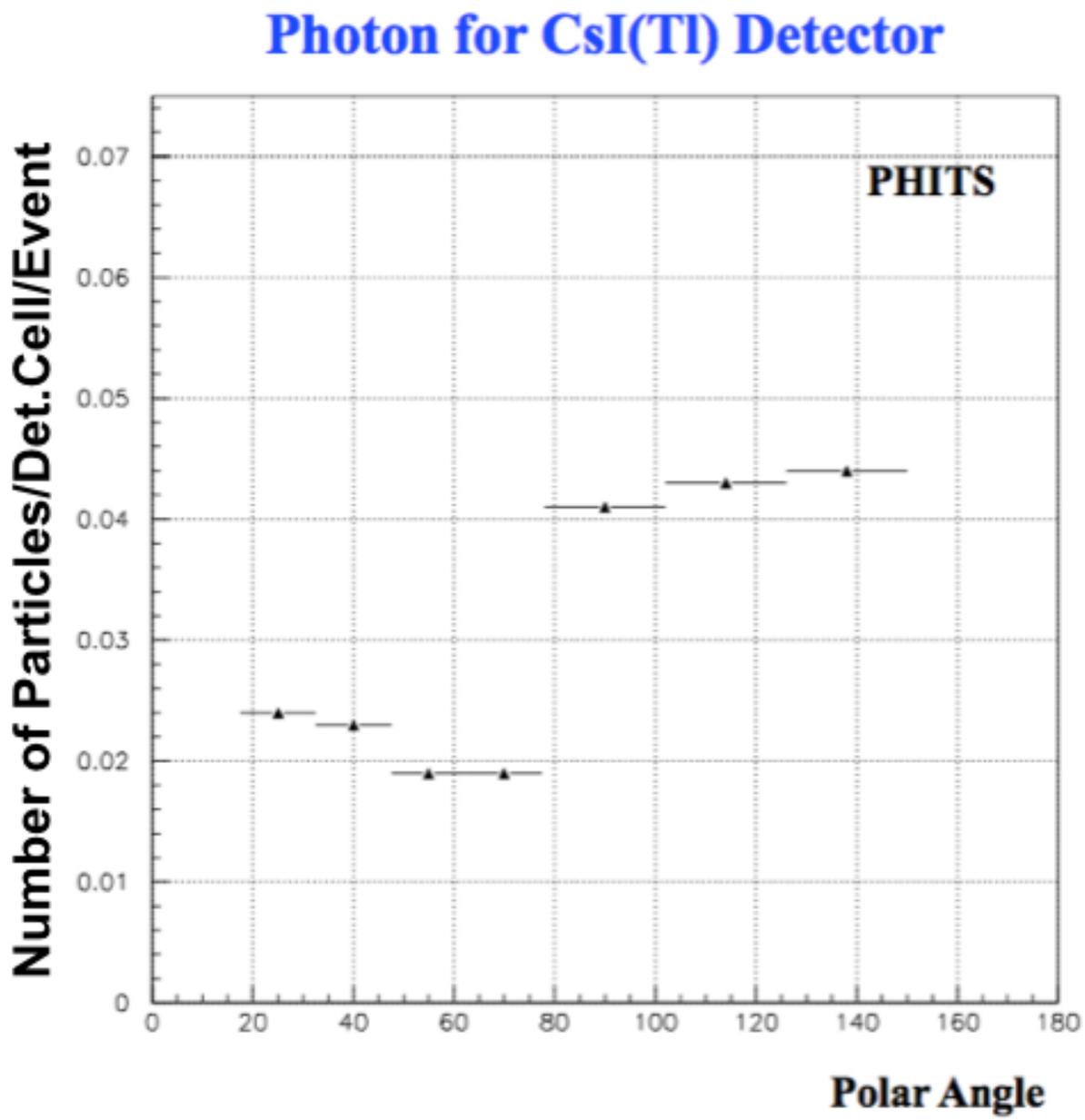
Sphere Detector : Cover Range 36 ~ 144 degree, ToF Dist. : 1.1m
# of unit detector 368

Theta angle	Phi angle division	# of super (unit detector)
45 degree	30.0 degree	12 (48)
63 degree	22.5 degree	16 (64)
81 degree	20.0 degree	18 (72)
99 degree	20.0 degree	18 (72)
117 degree	22.5 degree	16 (64)
135 degree	30.0 degree	12 (48)

Total # of unit detector (0 ~ 144 degree) = 452
Total # of unit detector (0 ~ 90 degree) = 268

Design of Si/CsI for LAMPS-L



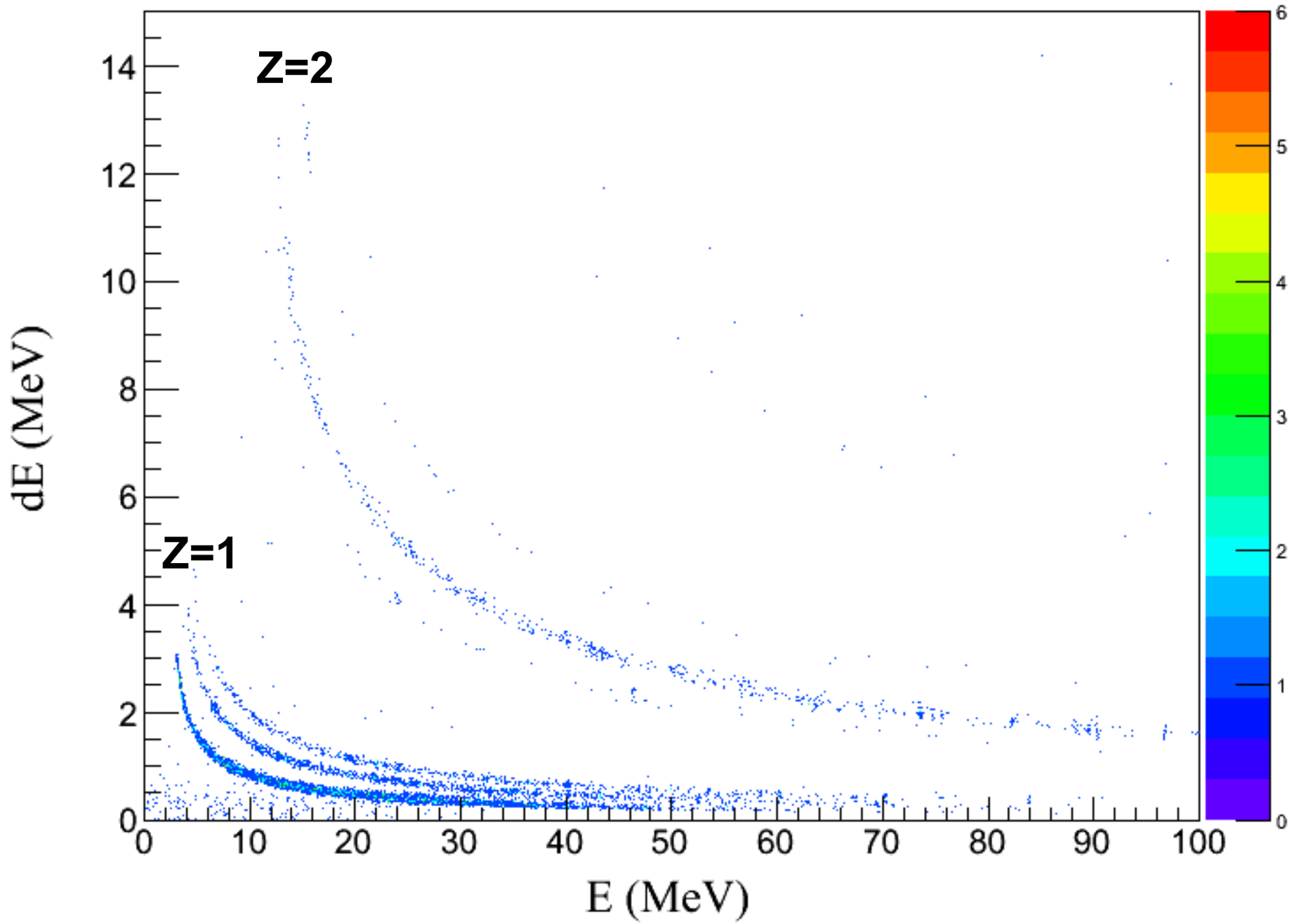


Det.CoverRange

	N_gen(△θ)	N_det(△θ)	Det.CovRange (%) (simulation)	Det.CovRange (%) (geometrical)	# of particle/ Det.cell/event	Occupancy
1 : (17.5°<θ<32.5°)	2.67	1.53	57.25	58.43	0.191	0.0156
2 : (32.5°<θ<47.5°)	1.98	1.14	57.56	57.62	0.095	0.0077
3 : (47.5°<θ<62.5°)	1.71	1.14	66.88	67.81	0.063	0.0052
4 : (62.5°<θ<77.5°)	1.17	0.73	62.33	65.69	0.037	0.0030
5 : (77.5°<θ<102°)	1.10	0.84	76.36	79.11	0.056	0.0046
6 : (102°<θ<126°)	0.56	0.37	67.47	70.70	0.031	0.0025
7 : (126°<θ<150°)	0.25	0.14	57.03	64.35	0.018	0.0014

PID : dE – E method

(used AMD events. CsI thickness : 5cm)



Geant4 Simulation

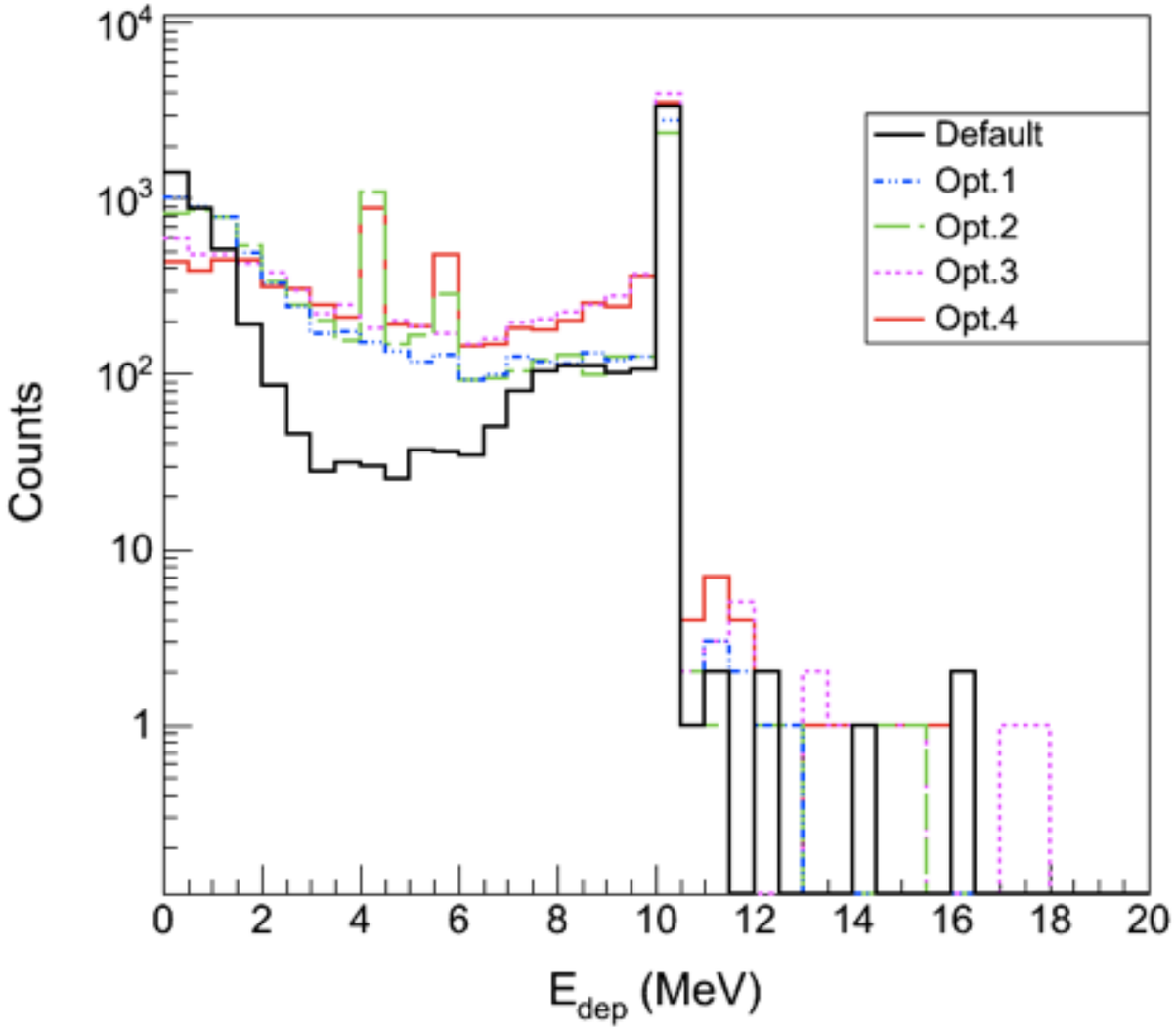
- Package 1 : Hadron Physics - HadronPhysicsQGSP_BERT
- Package 2 : Hadron Physics - HadronPhysicsQGSP_BIC
- Package 3 : Hadron Physics - G4HadronElasticPhysics
- Package 4 : Decay Physics - G4RadioactiveDecayPhysics
- Tested 5 different combinations

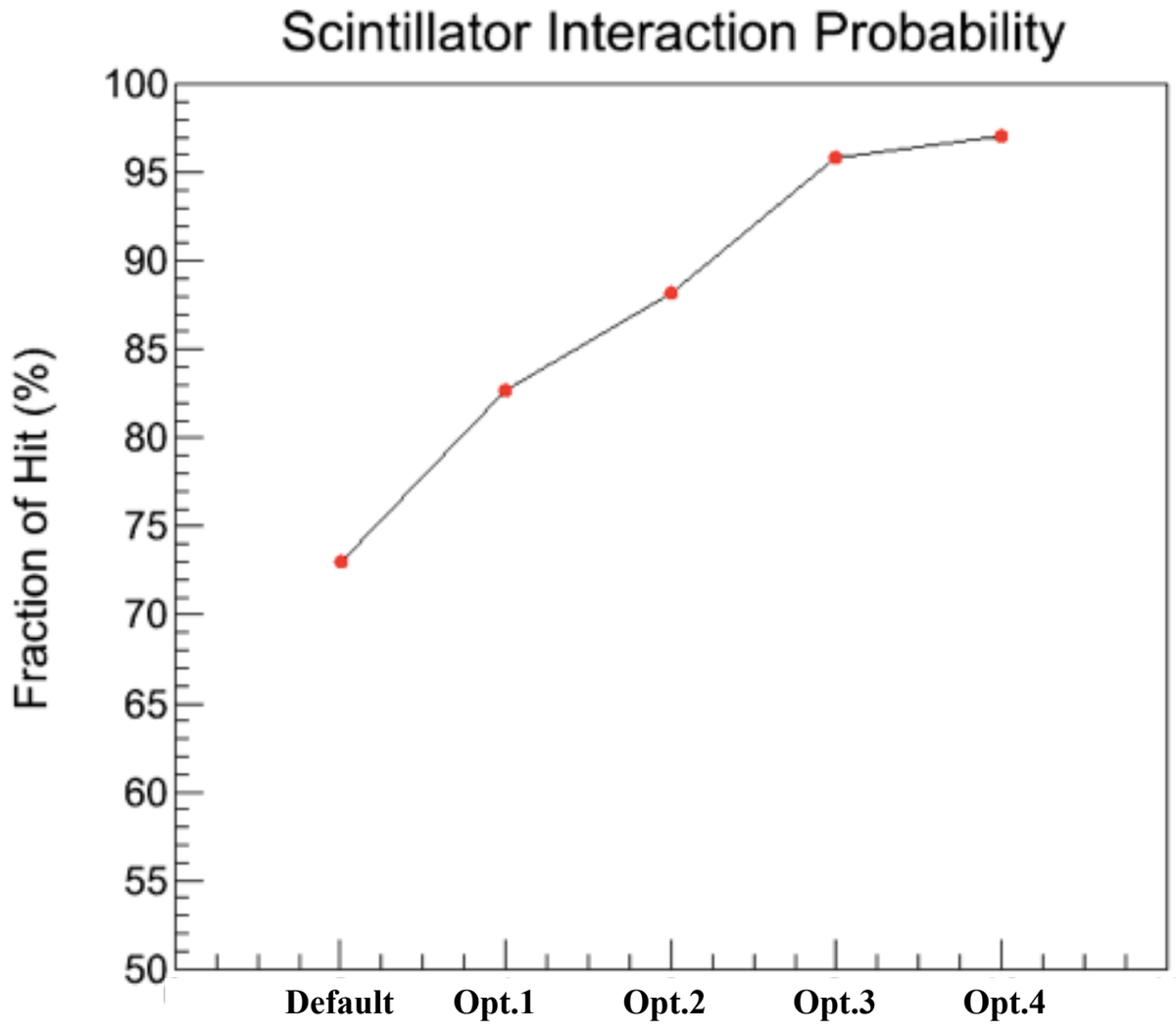
Default	Default
Opt.1	Default+Pack.1
Opt.2	Default+Pack.1 +Pack.2
Opt.3	Default+Pack.1+Pack.3 +Pack.4
Opt.4	Default+Pack.1+Pack.2 +Pack.3 +Pack.4

Response of Neutron Detector

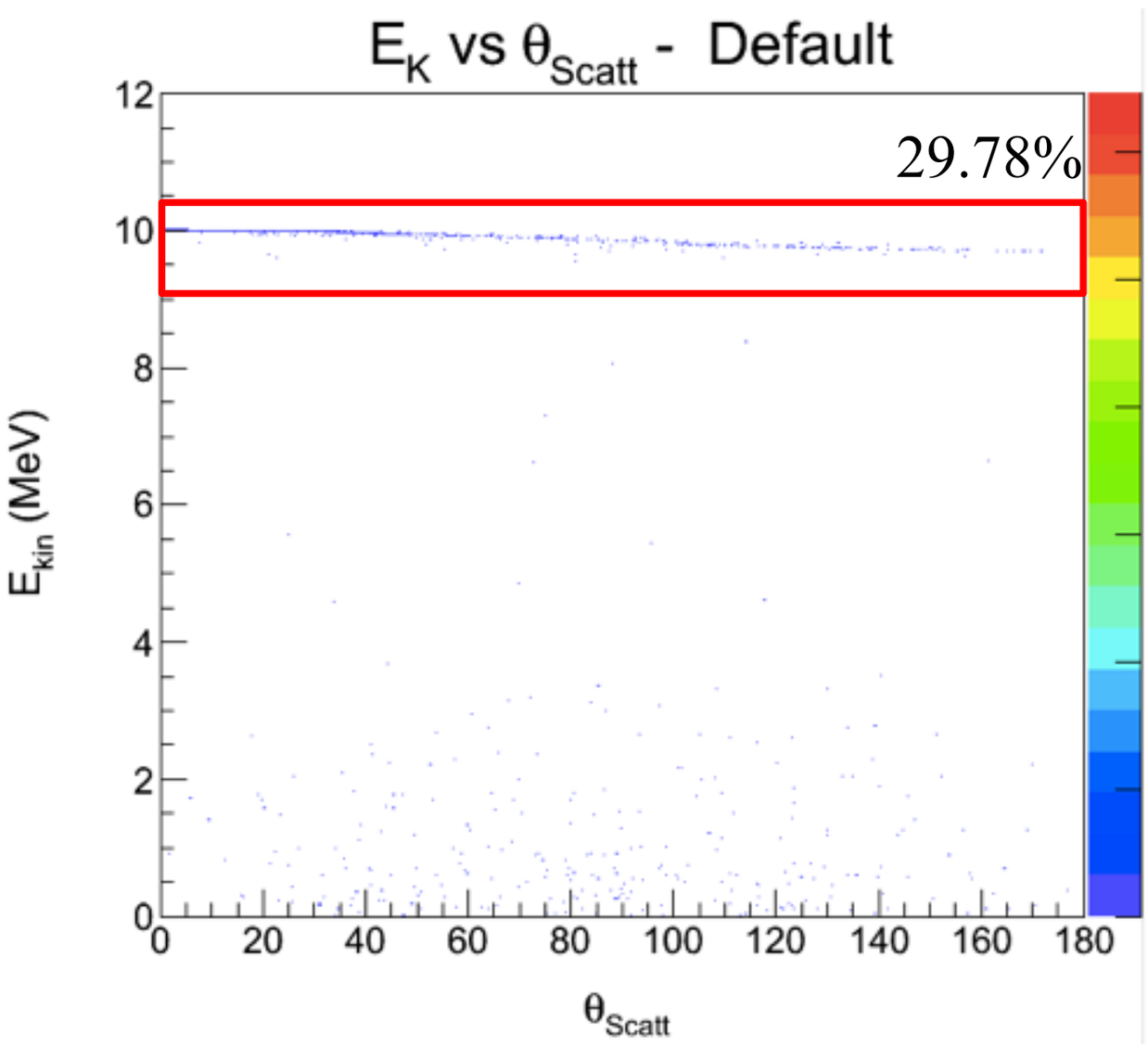
E_{beam} = 10 MeV

# of Event = 10,000





Kinetic Energy vs Scattering Angle (CsI Thickness : 5cm)



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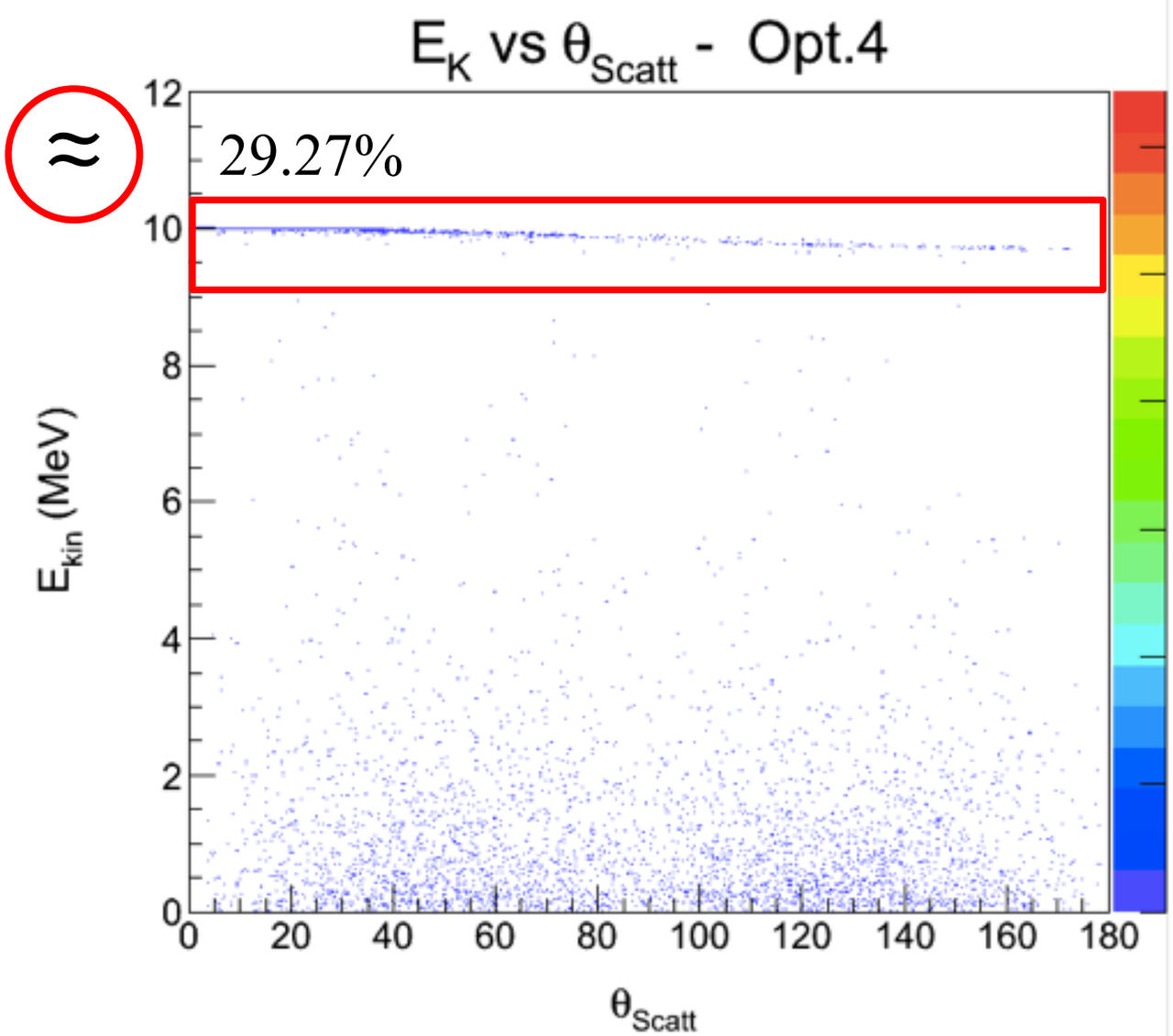
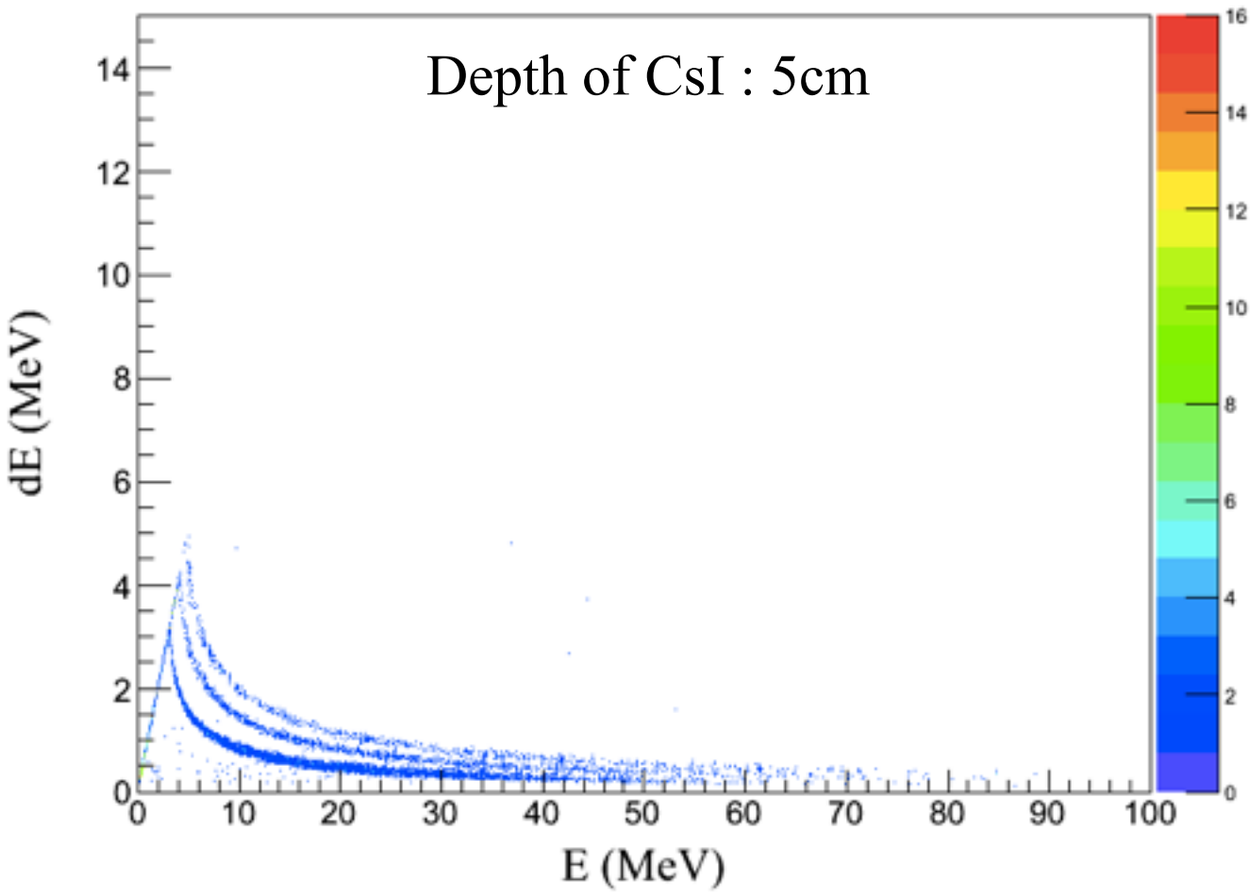
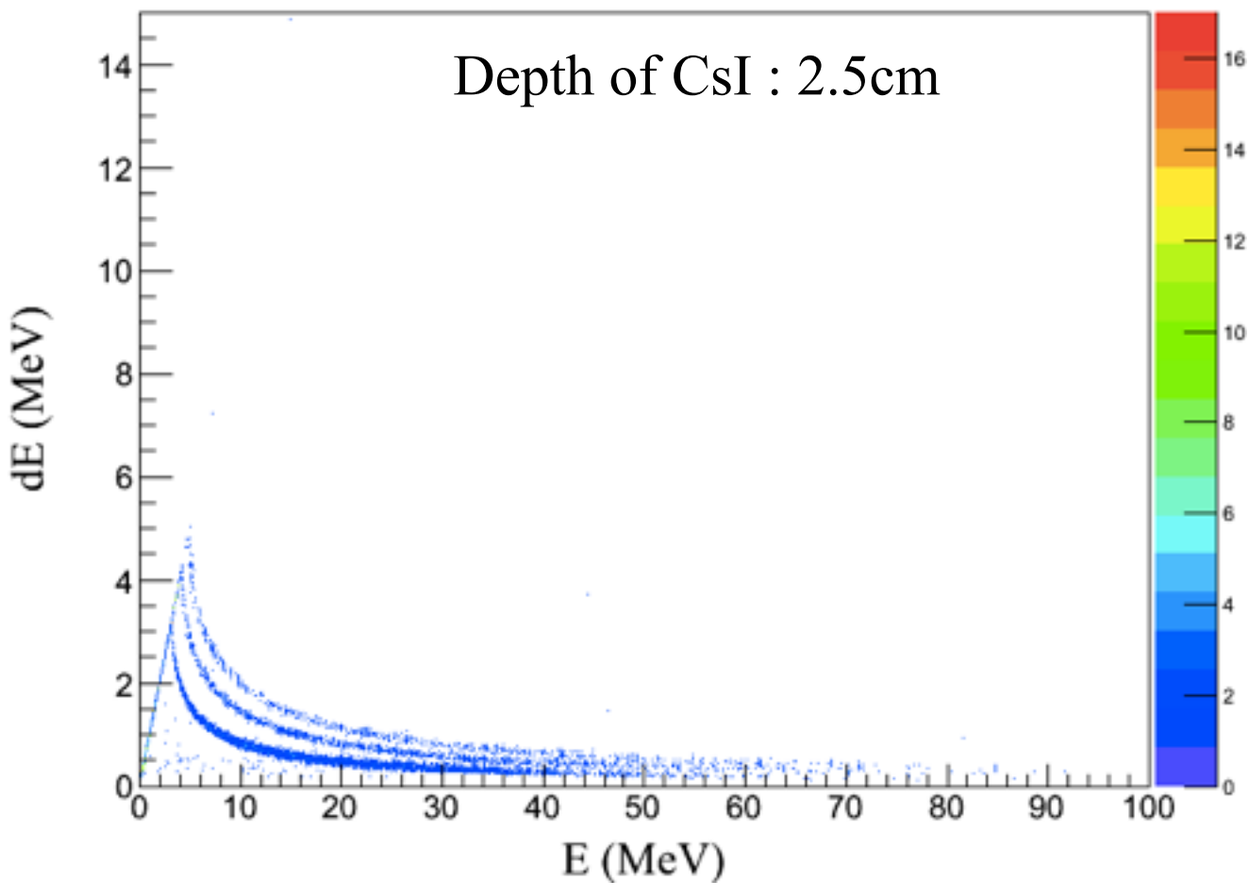


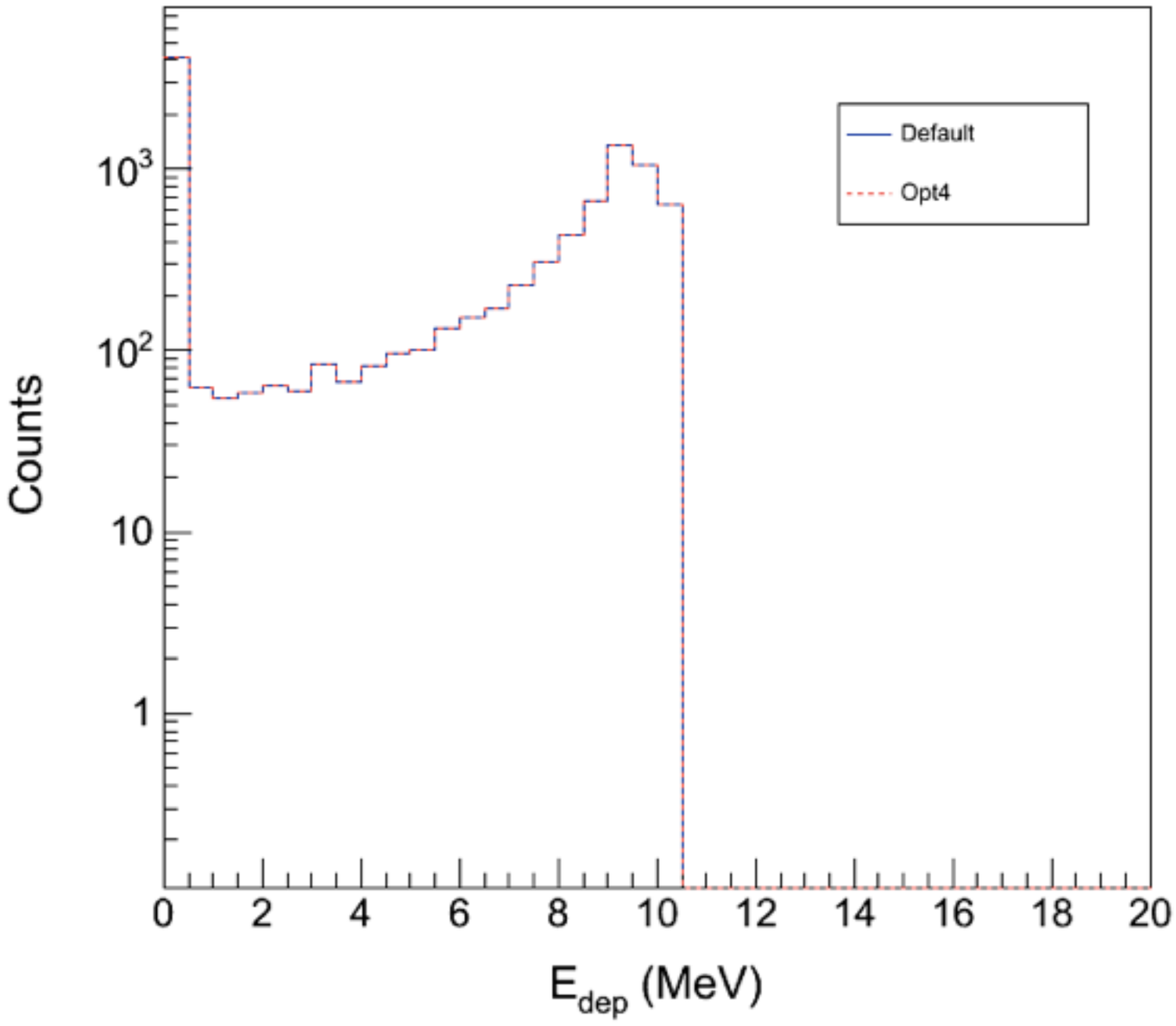
CsI thickness effect on charged particle

<Proton Isotope AMD Generated Events>





Gamma Efficiency



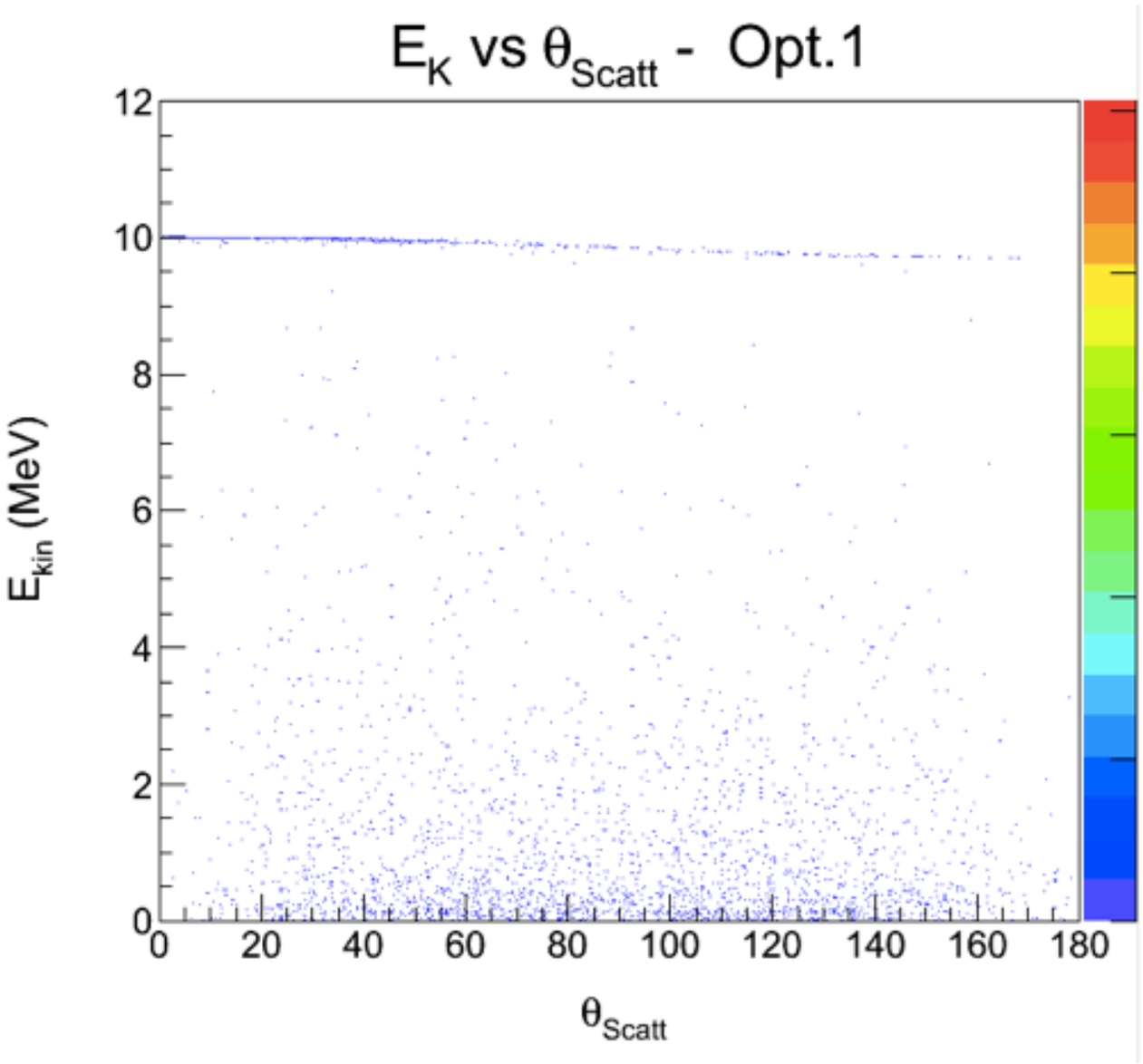
Total

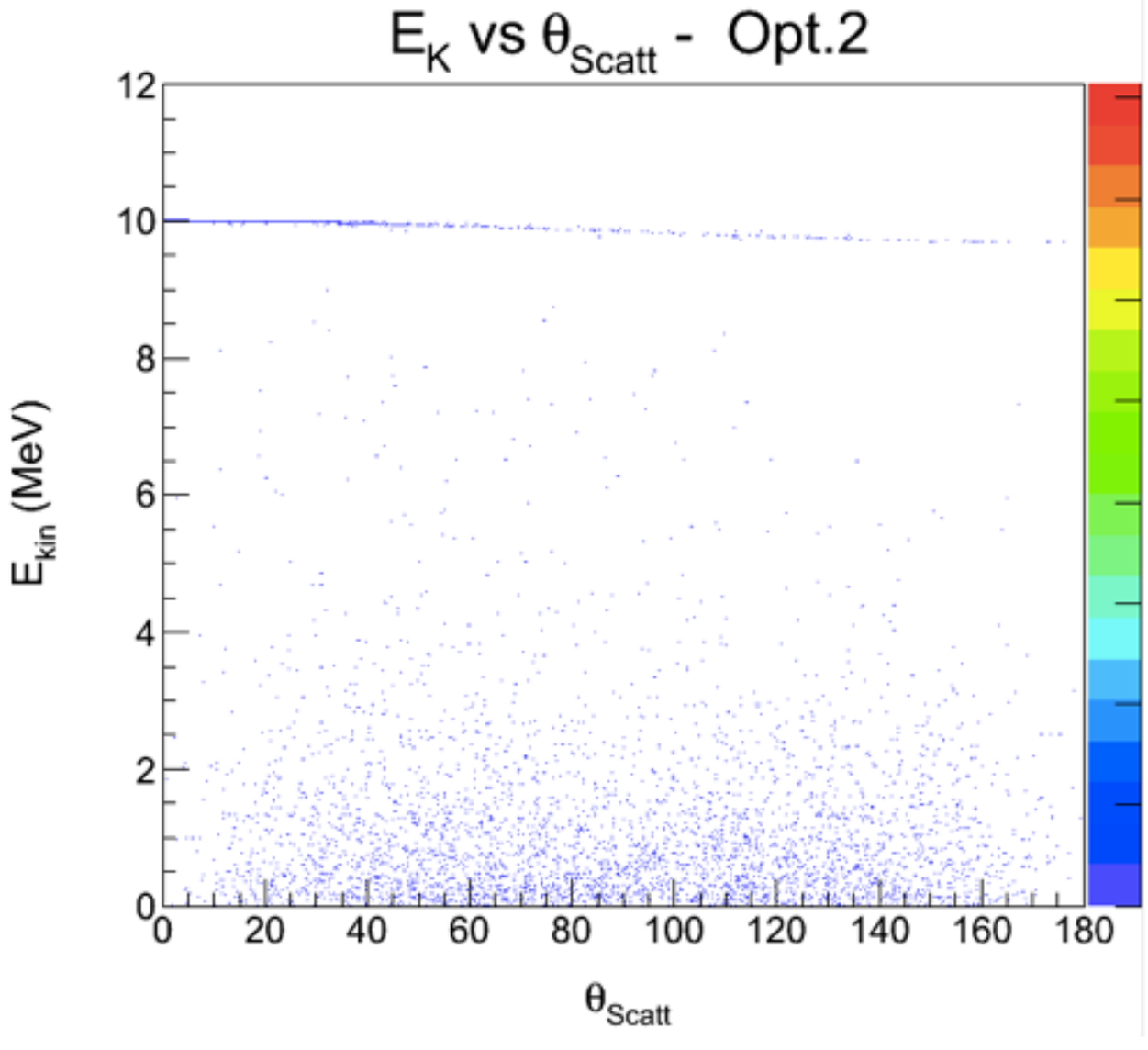
Summary & Plan

- Charged Particle full absorption check
  - veto scintillator?

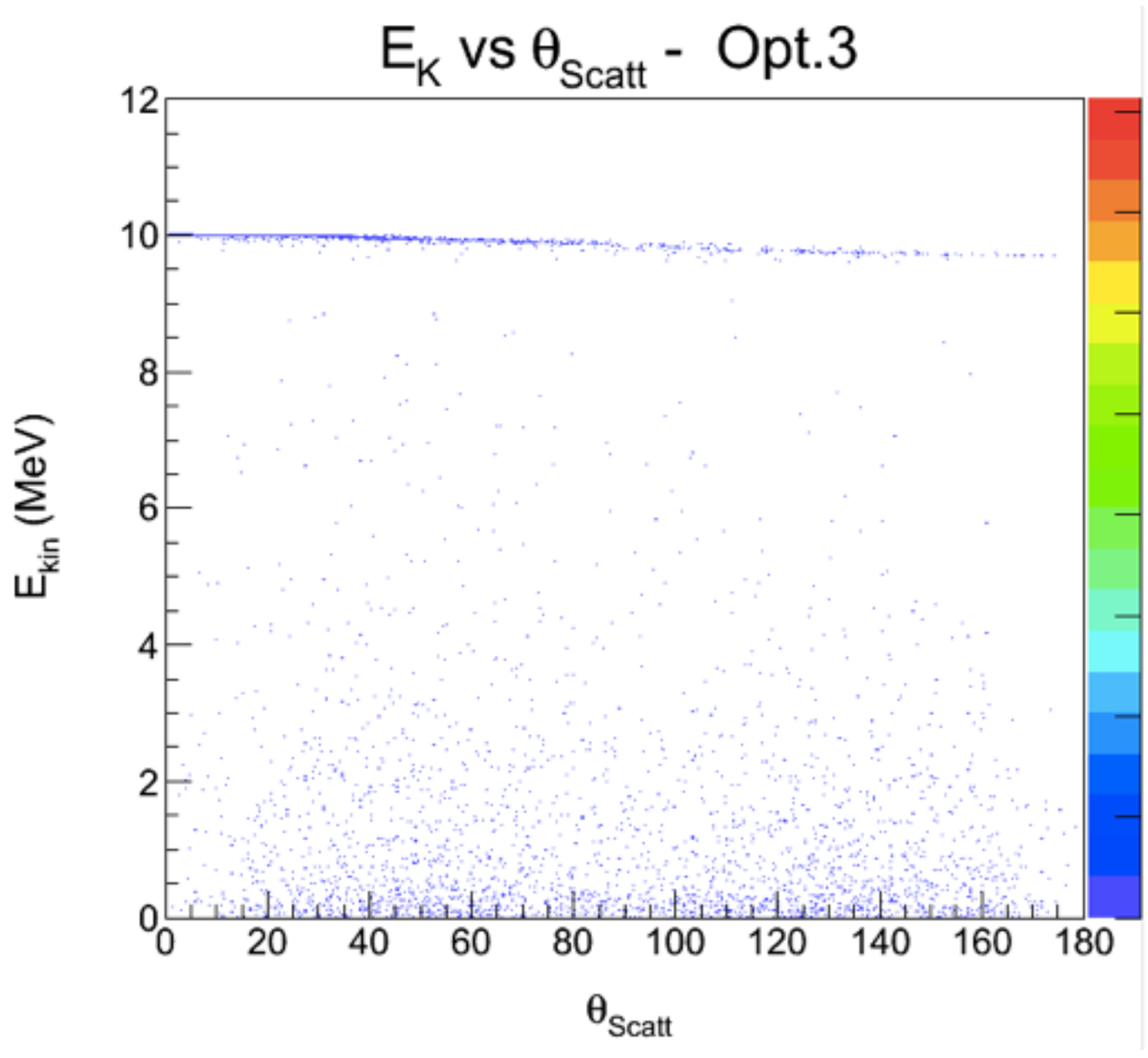
- Background, Efficiency study for scattering neutrons in CsI - Paper? Experiment?

Effect of Si-CsI Detector

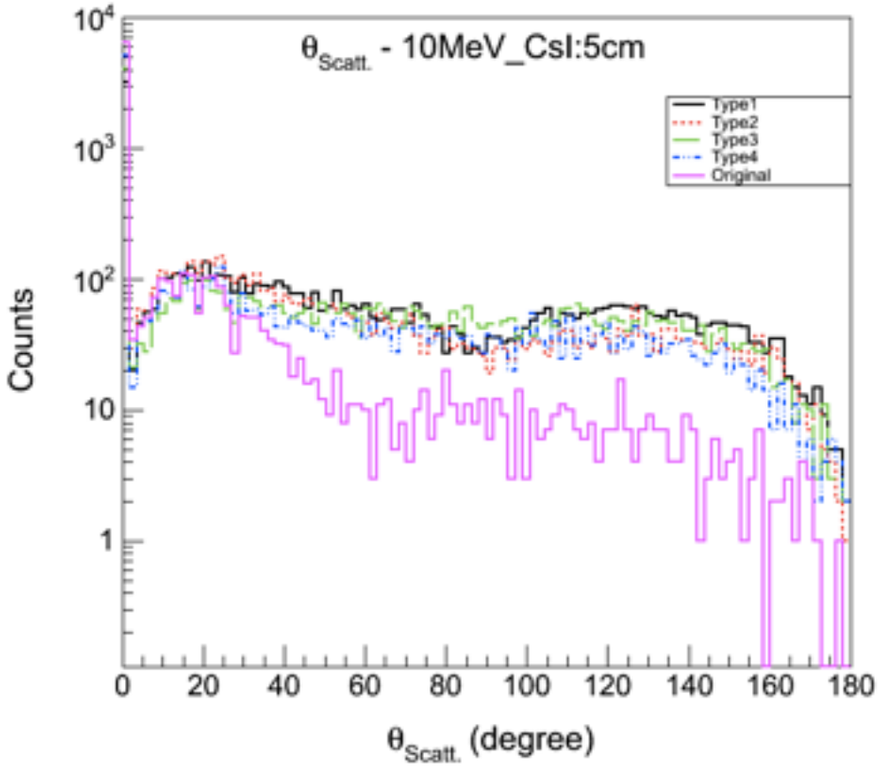


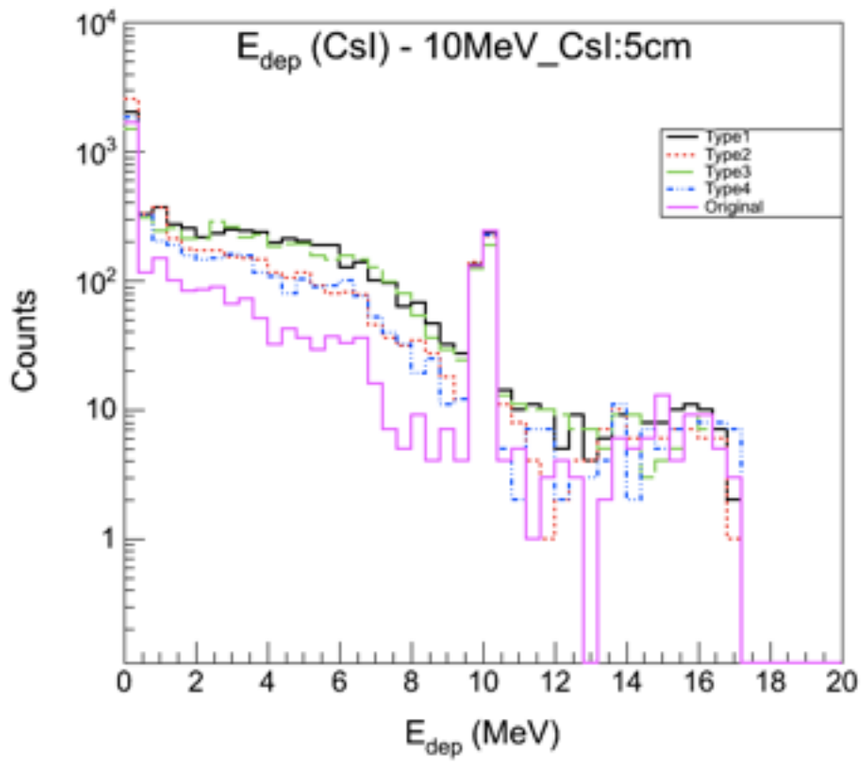


Effect of Si-CsI Detector



Neutron Scattering Angle in CsI (10MeV, 10000events, 5cm)





$N_{\theta<10^\circ}$: # of neutron $\theta<10^\circ$
N_{CsIHit} : # of E_{dep} neutrons in CsI
$N_{Edep>1MeV}$: # of E_{dep} > 1MeV in CsI

Type1
$N_{\theta<10^\circ}$ = 3454 (34.34%)
N_{CsIHit} = 6620 (66.20%)
$N_{Edep>1MeV}$ = 4077 (40.77%)

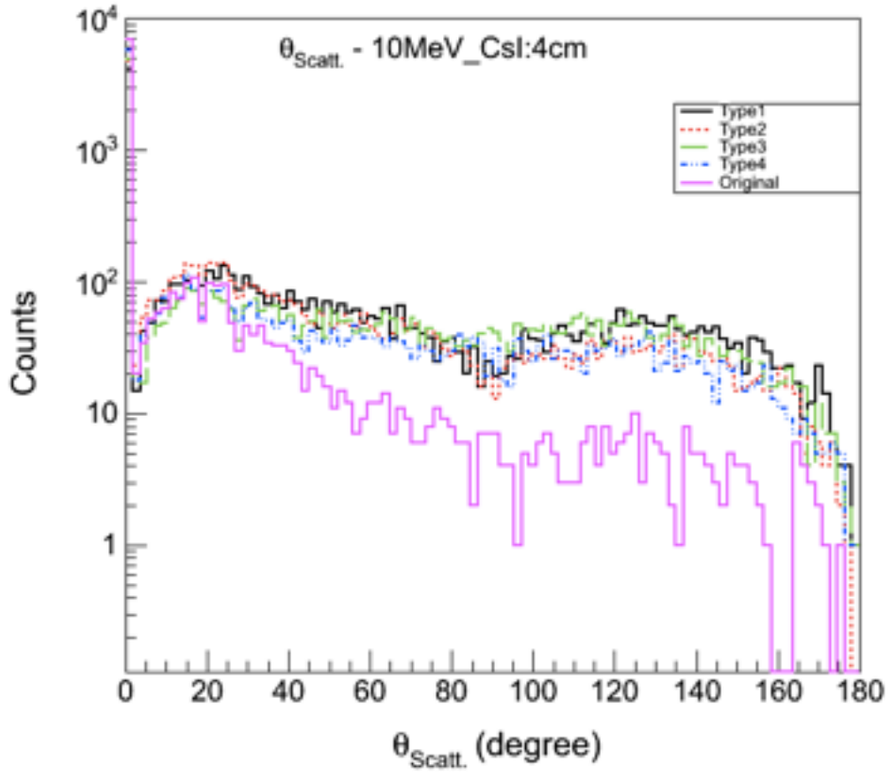
Type2
$N_{\theta<10^\circ}$ = 4368 (43.68%)
N_{CsIHit} = 5752 (57.52%)
$N_{Edep>1MeV}$ = 2681 (26.81%)

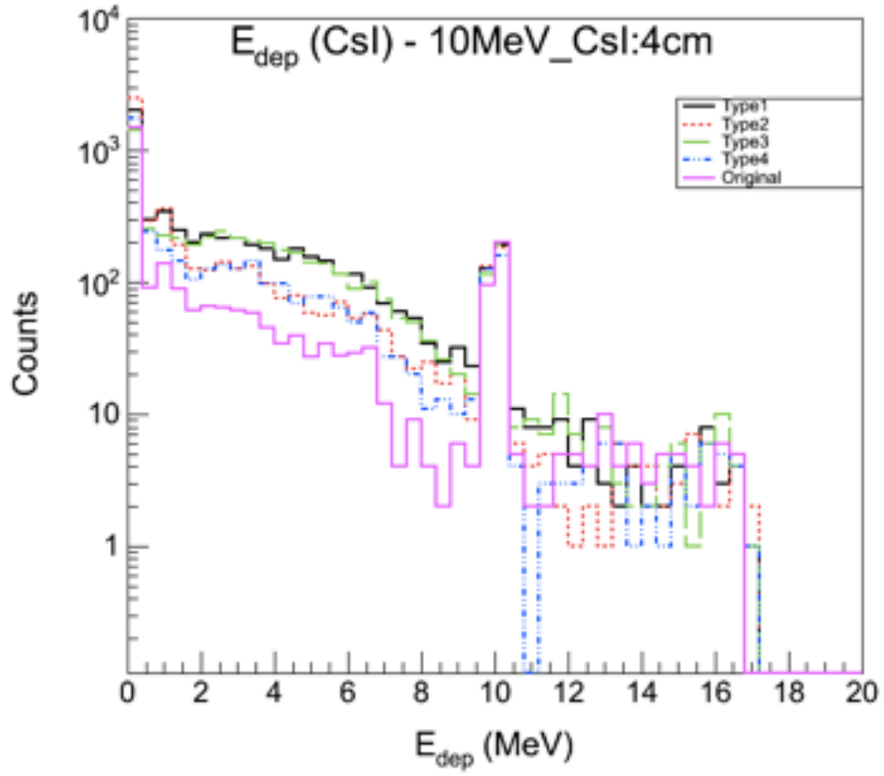
Type3
$N_{\theta<10^\circ}$ = 4231 (42.31%)
N_{CsIHit} = 5748 (57.48%)
$N_{Edep>1MeV}$ = 3833 (38.33%)

Type4
$N_{\theta<10^\circ}$ = 5262 (52.62%)
N_{CsIHit} = 4714 (47.14%)
$N_{Edep>1MeV}$ = 2456 (24.56%)

Original
$N_{\theta<10^\circ}$ = 6732 (67.32%)
N_{CsIHit} = 3245 (32.45%)
$N_{Edep>1MeV}$ = 1371 (13.71%)

Neutron Scattering Angle in CsI (10MeV, 10000events, 4cm)





$N_{\theta<10^\circ}$: # of neutron $\theta<10^\circ$
N_{CsIHit} : # of E_{dep} neutrons in CsI
$N_{Edep>1MeV}$: # of E_{dep} > 1MeV in CsI

Type1
$N_{\theta<10^\circ}$ = 4317 (43.17%)
N_{CsIHit} = 5769 (57.69%)
$N_{Edep>1MeV}$ = 3303 (33.03%)

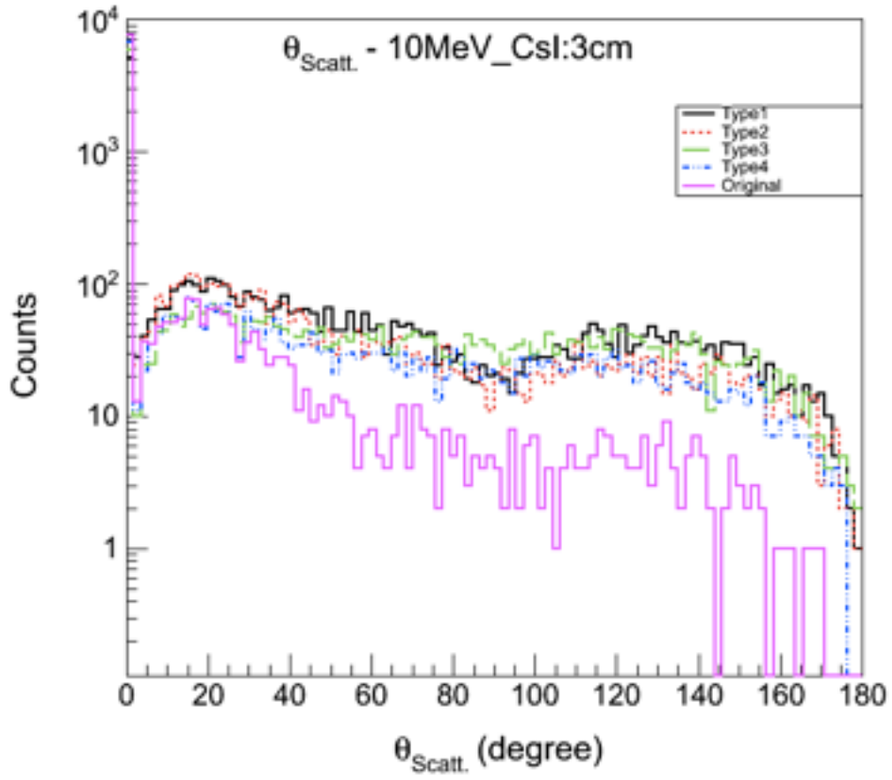
Type2
$N_{\theta<10^\circ}$ = 5067 (50.67%)
N_{CsIHit} = 5035 (50.35%)
$N_{Edep>1MeV}$ = 2081 (20.81%)

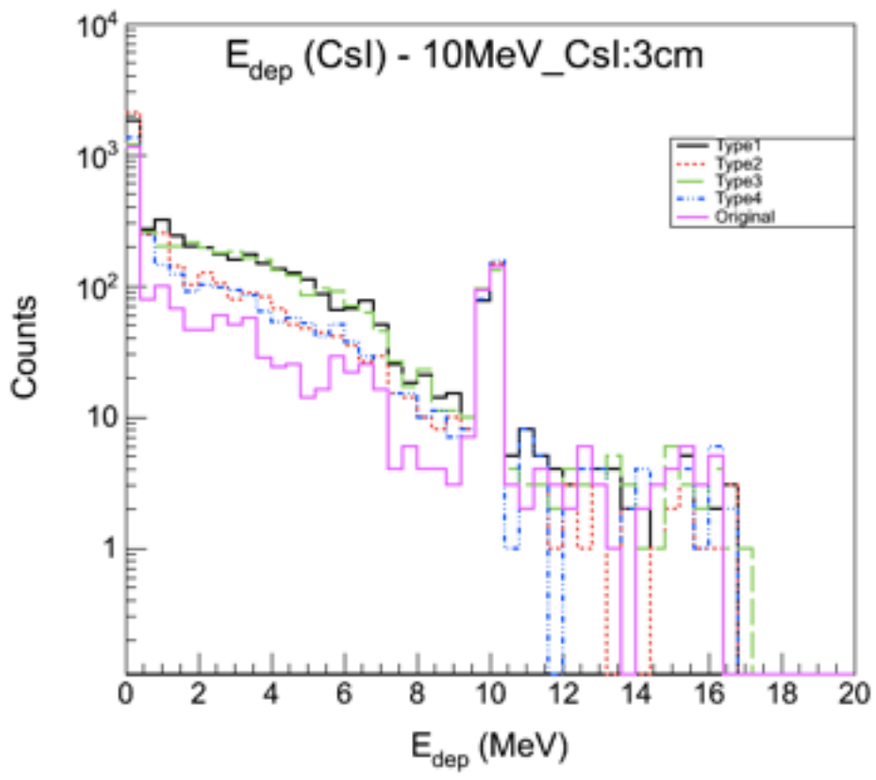
Type3
$N_{\theta<10^\circ}$ = 5000 (50.00%)
N_{CsIHit} = 4985 (49.85%)
$N_{Edep>1MeV}$ = 3205 (32.05%)

Type4
$N_{\theta<10^\circ}$ = 5994 (59.94%)
N_{CsIHit} = 3991 (39.91%)
$N_{Edep>1MeV}$ = 1921 (19.21%)

Original
$N_{\theta<10^\circ}$ = 7157 (71.57%)
N_{CsIHit} = 2794 (27.94%)
$N_{Edep>1MeV}$ = 1160 (11.60%)

Neutron Scattering Angle in CsI (10MeV, 10000events, 3cm)





$N_{\theta<10^\circ}$: # of neutron $\theta<10^\circ$
N_{CsIHit} : # of E_{dep} neutrons in CsI
$N_{Edep>1MeV}$: # of E_{dep} > 1MeV in CsI

Type1
$N_{\theta<10^\circ}$ = 5285 (52.85%)
N_{CsIHit} = 4766 (47.66%)
$N_{Edep>1MeV}$ = 2521 (25.21%)

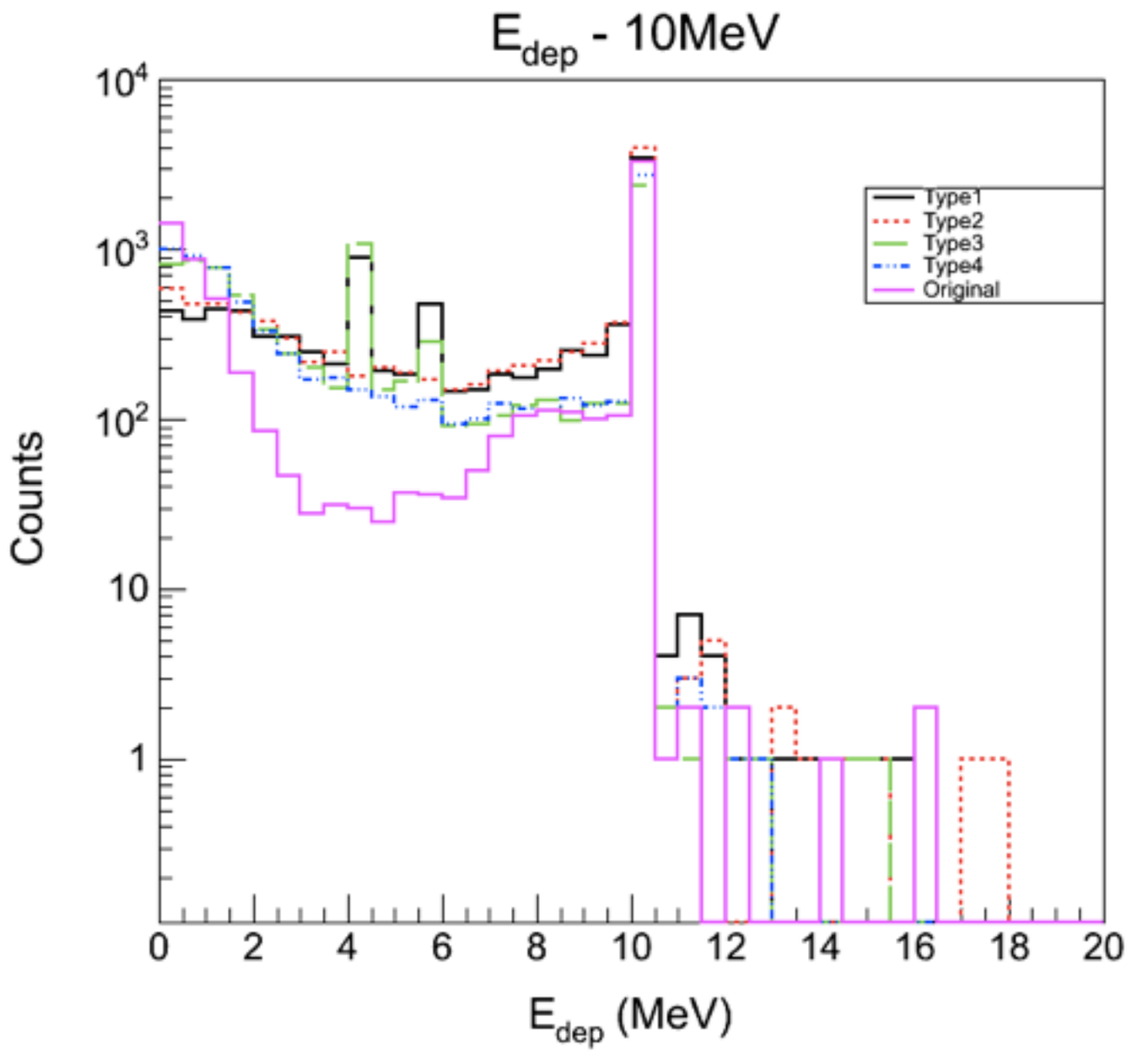
Type2
$N_{\theta<10^\circ}$ = 6089 (60.89%)
N_{CsIHit} = 3992 (39.92%)
$N_{Edep>1MeV}$ = 1507 (15.07%)

Type3
$N_{\theta<10^\circ}$ = 5973 (59.73%)
N_{CsIHit} = 3996 (39.96%)
$N_{Edep>1MeV}$ = 2452 (24.52%)

Type4
$N_{\theta<10^\circ}$ = 6867 (68.67%)
N_{CsIHit} = 3065 (30.65%)
$N_{Edep>1MeV}$ = 1400 (14.00%)

Original
$N_{\theta<10^\circ}$ = 7786 (77.86%)
N_{CsIHit} = 2142 (21.42%)
$N_{Edep>1MeV}$ = 883 (8.83%)

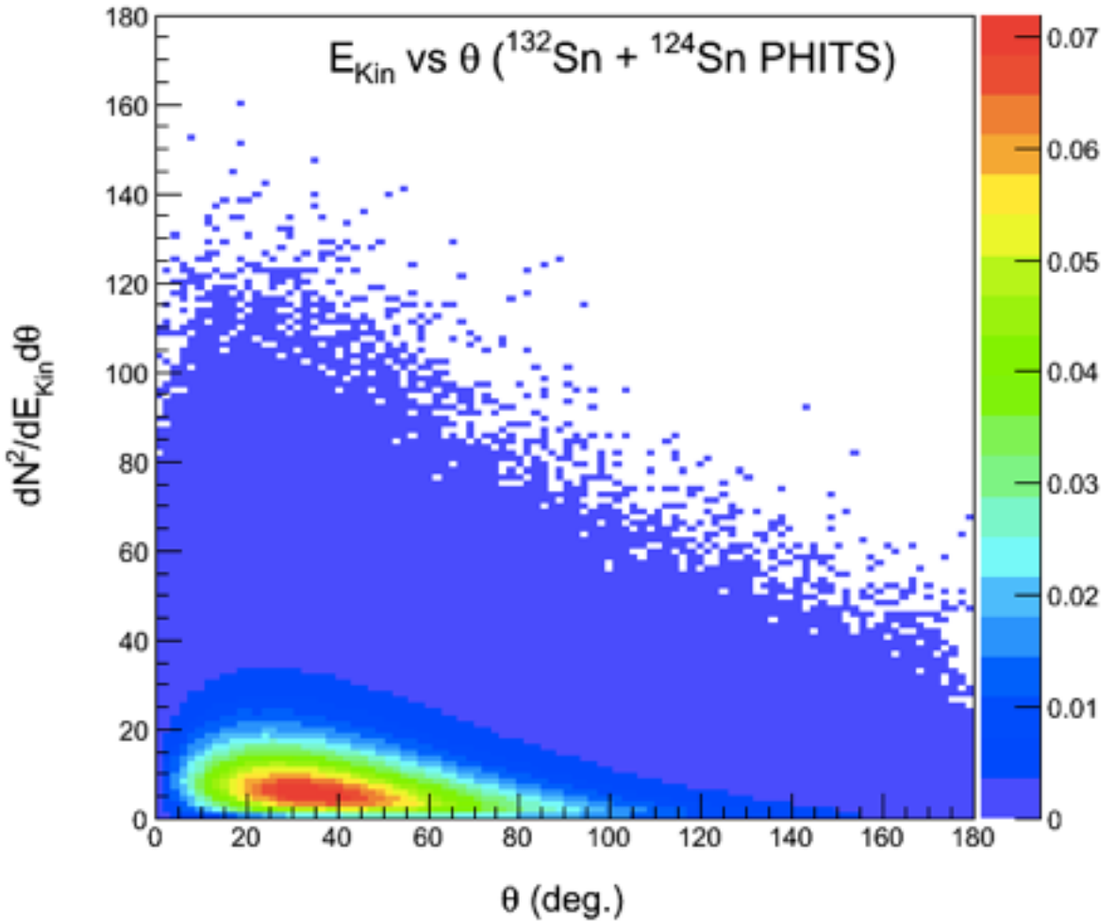
Neutron Scattering Angle in Scint (10MeV, 10000events)

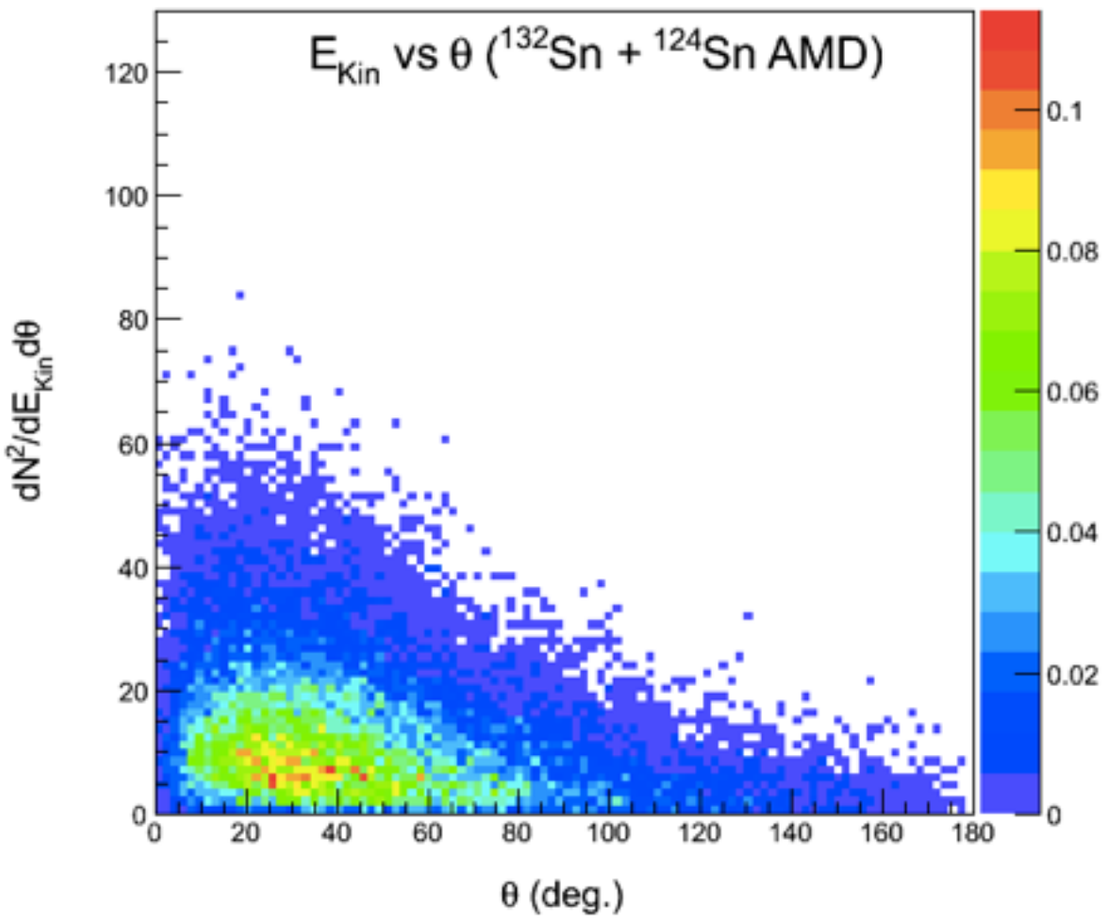


$N_{ScintHit}$: # of E_{dep} neutrons in Scint
N_{Full} : # of E_{dep} > 10MeV (Full absorption)

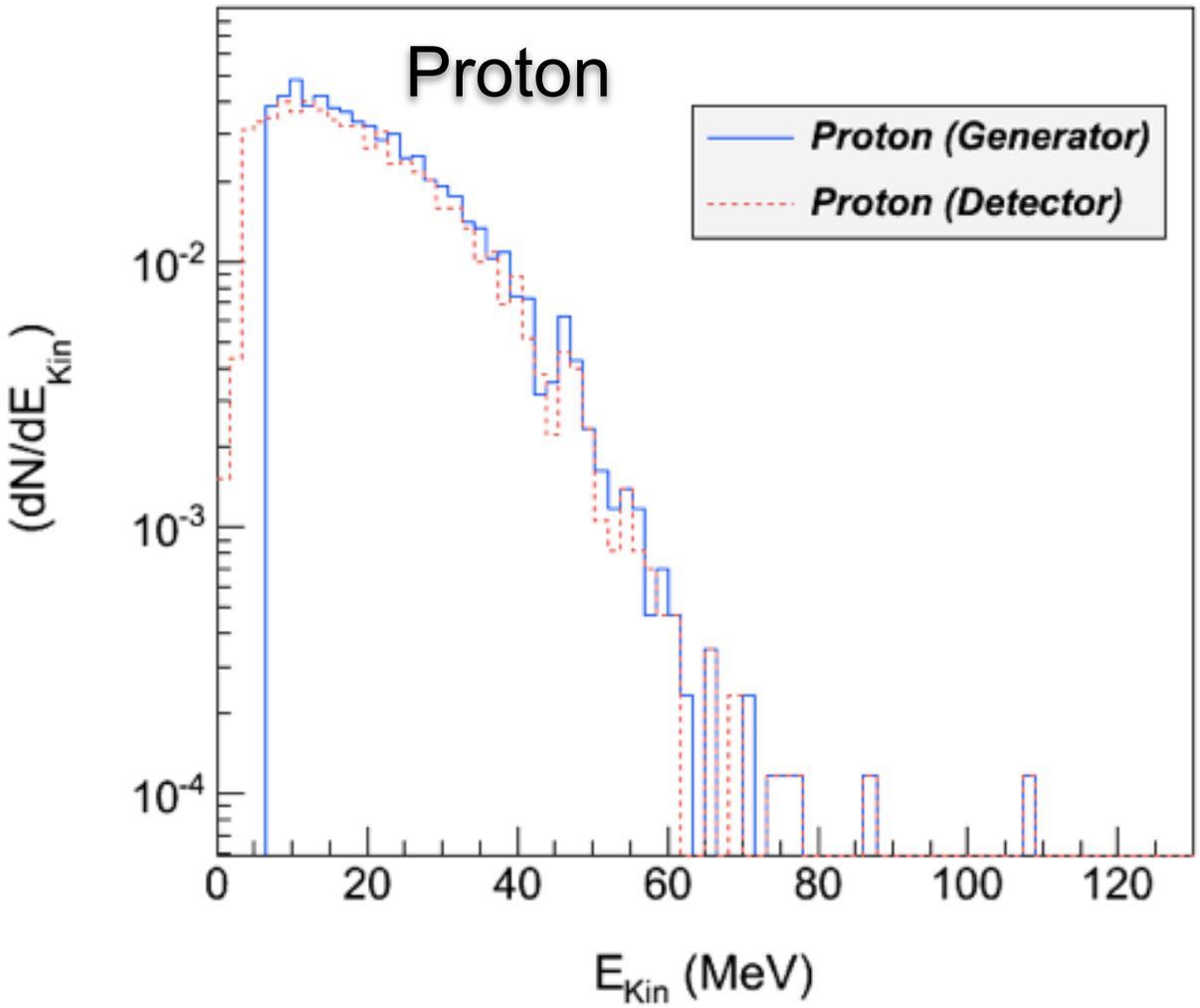
Type1 $N_{ScintHit}$ = 9701 (97.01%) N_{Full} = 3851 (38.51%)	Type2 $N_{ScintHit}$ = 9588 (95.88%) N_{Full} = 4302 (43.02%)
Type3 $N_{ScintHit}$ = 8820 (88.20%) N_{Full} = 2478 (24.78%)	Type4 $N_{ScintHit}$ = 8266 (82.66%) N_{Full} = 2873 (28.73%)
Orginal $N_{ScintHit}$ = 7305 (73.05%) N_{Full} = 3414 (34.14%)	

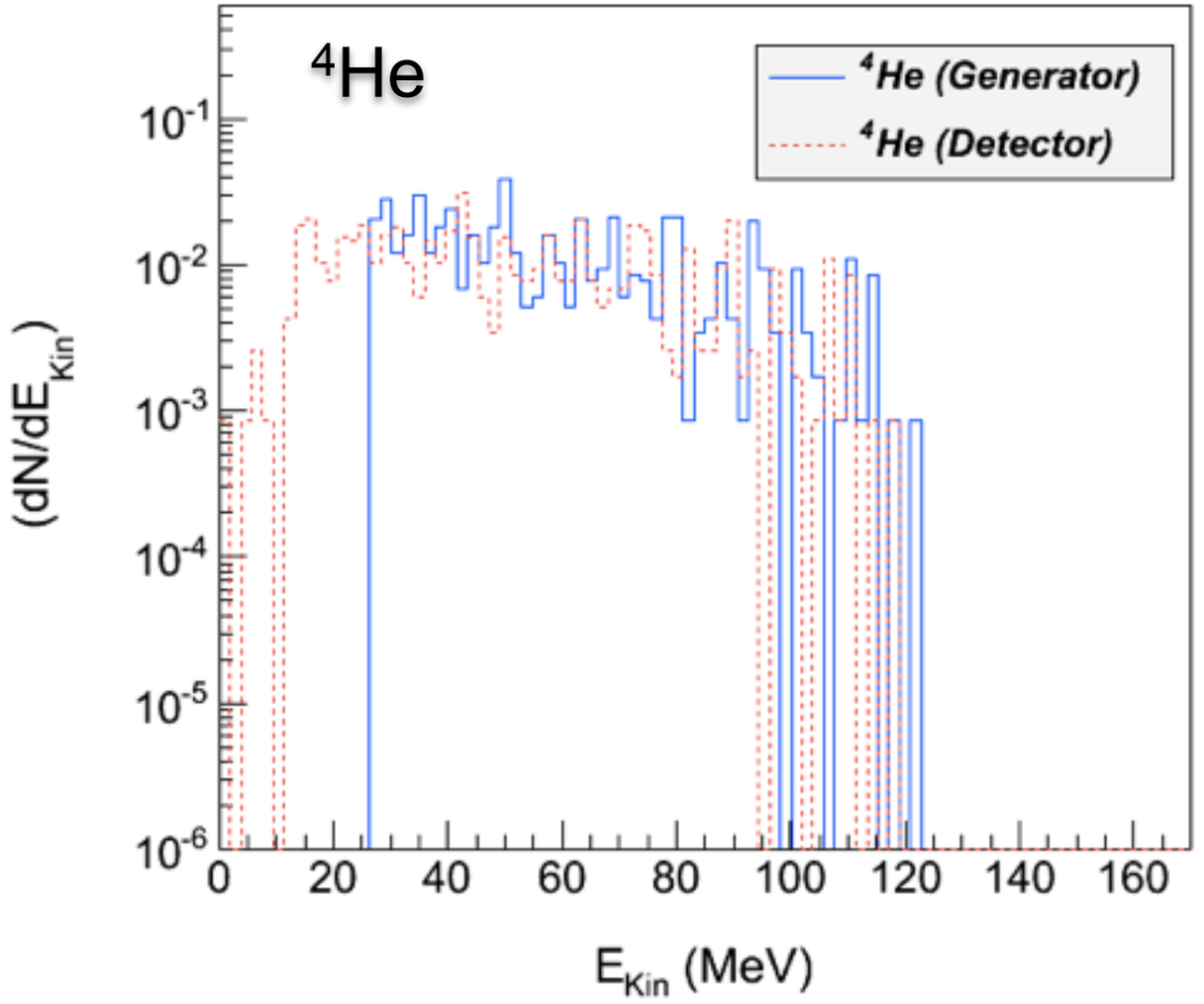
AMD & PHITS Neutron





Kinetic Energy Detector & AMD Generator Events

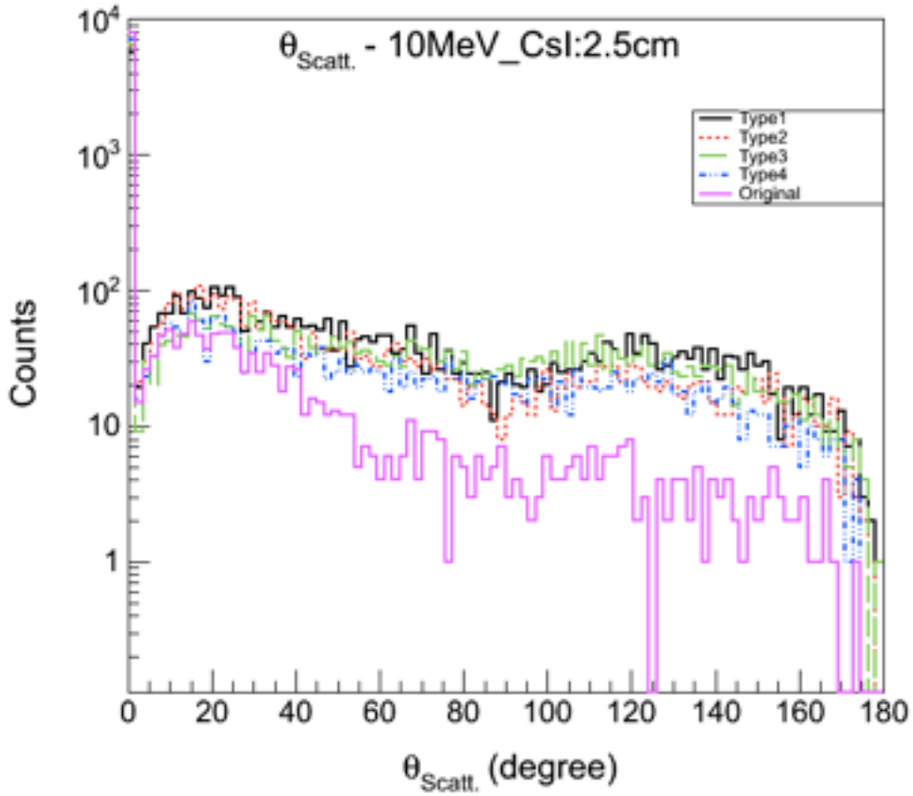


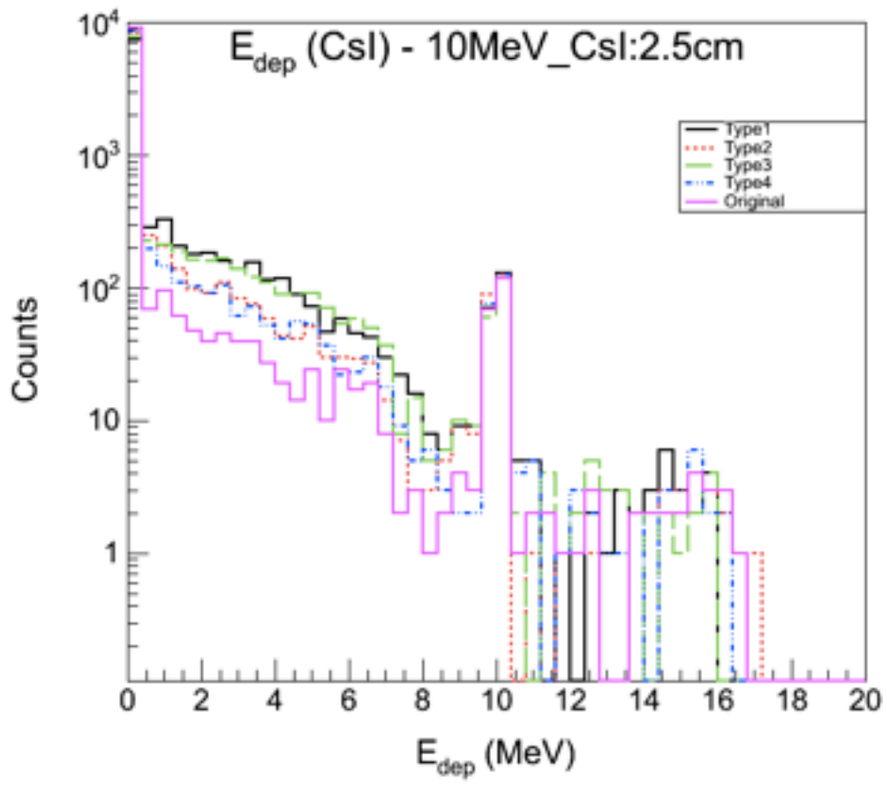


$^{132}Sn+^{124}Sn$ - AMD&PHITS

	AMD	PHITS
Number of Events	N(event) = 2010	N(event) = 272018
Number of particles (per event)	<N> = 62.047	<N>=52.040
Number of Neutrons (per event)	< neutron> = 49.783 (80.23%)	< neutron>=33.138 (63.68%)
Number of Charged Particles (per event)	< charged>= 12.265 (19.77%)	< charged>=15.986 (30.72%)
Number of Protons (per event)	< proton> = 5.213 (8.40%)	< proton>=10.059 (19.33%)
Number of Gammas	no gammas	<gammas>=2.916 (5.60%)

Neutron Scattering Angle in CsI (10MeV, 10000events, 2.5cm)





$N_{\theta<10^\circ}$: # of neutron $\theta<10^\circ$
N_{CsIHit} : # of E_{dep} neutrons in CsI
$N_{Edep>1MeV}$: # of E_{dep} > 1MeV in CsI

Type1	Type2
$N_{\theta<10^\circ}$ = 5824 (58.24%)	$N_{\theta<10^\circ}$ = 6562 (65.62%)
N_{CsIHit} = 4265 (42.65%)	N_{CsIHit} = 3493 (34.93%)
$N_{Edep>1MeV}$ = 2092 (20.92%)	$N_{Edep>1MeV}$ = 1278 (12.78%)

Type3	Type4	Original
$N_{\theta<10^\circ}$ = 6517 (65.17%)	$N_{\theta<10^\circ}$ = 7221 (72.21%)	$N_{\theta<10^\circ}$ = 8148 (81.48%)
N_{CsIHit} = 3456 (34.56%)	N_{CsIHit} = 2754 (27.54%)	N_{CsIHit} = 1805 (18.05%)
$N_{Edep>1MeV}$ = 1956 (19.56%)	$N_{Edep>1MeV}$ = 1212 (12.12%)	$N_{Edep>1MeV}$ = 713 (7.13%)

: PHITS, **Photons**

$< N_{photon} > = N_{Det} \times R$ (for **CsI Detector)**

S : Area of one detector (**X=√S**), **r= 40cm** (Distance from target),

N(△θ) : Number of particles per event, **N_Det** : Number of detectors.

Bin	N(△θ)	N_Det	S(cm^2)	X(cm)	R
1 : (17.5°<θ<32.5°)	0.19	8	81.0	9.0	0.024
2 : (32.5°<θ<47.5°)	0.28	12	81.0	9.0	0.023
3 : (47.5°<θ<62.5°)	0.34	18	81.0	9.0	0.019
4 : (62.5°<θ<77.5°)	0.38	20	81.0	9.0	0.019
5 : (77.5°<θ<102°)	0.61	15	225.0	15.0	0.041
6 : (102°<θ<126°)	0.51	12	225.0	15.0	0.043
7 : (126°<θ<150°)	0.35	8	225.0	15.0	0.044
Sum	2.66	93			

: PHITS : AMD, **Charged Particles**

$< N_{charged} > = N_{Det} \times R$ (for **Si Detector**)

S : Area of one detector (**X=√S**), **r= 40cm** (Distance from target),

N(△θ) : Number of particles per event, **N_Det** : Number of detectors.

Bin	N(△θ)	N_Det	S(cm^2)	X(cm)	R	N(△θ)	N_Det	S(cm^2)	X(cm)	R
1 : (17.5°<θ<22.5°)	0.99	24	9.0	3.0	0.041	0.99	24	9.0	3.0	0.041
2 : (22.5°<θ<27.5°)	1.05	24	9.0	3.0	0.044	0.87	24	9.0	3.0	0.036
3 : (27.5°<θ<32.5°)	1.02	24	9.0	3.0	0.043	0.81	24	9.0	3.0	0.033
4 : (32.5°<θ<37.5°)	1.00	36	9.0	3.0	0.028	0.68	36	9.0	3.0	0.019
5 : (37.5°<θ<42.5°)	1.00	36	9.0	3.0	0.028	0.68	36	9.0	3.0	0.019
6 : (42.5°<θ<47.5°)	1.00	36	9.0	3.0	0.028	0.63	36	9.0	3.0	0.018
7 : (47.5°<θ<52.5°)	0.97	54	9.0	3.0	0.018	0.62	54	9.0	3.0	0.011
8 : (52.5°<θ<57.5°)	0.92	54	9.0	3.0	0.017	0.59	54	9.0	3.0	0.011
9 : (57.5°<θ<62.5°)	0.84	54	9.0	3.0	0.016	0.49	54	9.0	3.0	0.010
10 : (62.5°<θ<67.5°)	0.76	60	9.0	3.0	0.013	0.42	60	9.0	3.0	0.008
11 : (67.5°<θ<72.5°)	0.68	60	9.0	3.0	0.011	0.39	60	9.0	3.0	0.007
12 : (72.5°<θ<77.5°)	0.58	60	9.0	3.0	0.010	0.36	60	9.0	3.0	0.006
13 : (77.5°<θ<86°)	0.82	45	25.0	5.0	0.018	0.45	45	225.0	15.0	0.010
14 : (86°<θ<94°)	0.60	45	25.0	5.0	0.014	0.38	45	225.0	15.0	0.008
15 : (94°<θ<102°)	0.46	45	25.0	5.0	0.010	0.27	45	225.0	15.0	0.006
16 : (102°<θ<110°)	0.36	36	25.0	5.0	0.010	0.21	36	225.0	15.0	0.006
17 : (110°<θ<118°)	0.28	36	25.0	5.0	0.008	0.18	36	225.0	15.0	0.005
18 : (118°<θ<126°)	0.22	36	25.0	5.0	0.006	0.16	36	225.0	15.0	0.004
19 : (126°<θ<134°)	0.17	24	25.0	5.0	0.007	0.11	24	225.0	15.0	0.005
20 : (134°<θ<142°)	0.13	24	25.0	5.0	0.005	0.08	24	225.0	15.0	0.003
21 : (142°<θ<150°)	0.10	24	25.0	5.0	0.004	0.06	24	225.0	15.0	0.003
Sum	13.95	837				9.43	837			

: PHITS : AMD, **Neutron**

$< N_{neutron} > = N_{Det} \times R$ (for **Neutron Detector**)

S : Area of one detector (**X=√S**), **r= 300cm** (Distance from target),

N(△θ) : Number of particles per event, **N_Det** : Number of detectors.

Bin	N(△θ)	N_Det	S(cm^2)	X(cm)	R	N(△θ)	N_Det	S(cm^2)	X(cm)	R
1 : (0°<θ<5°)	0.37	14	100.0	10.0	0.026	0.66	14	100.0	10.0	0.047
2 : (5°<θ<10°)	1.09	36	100.0	10.0	0.030	2.13	36	100.0	10.0	0.059
3 : (10°<θ<15°)	1.74	64	100.0	10.0	0.027	3.01	64	100.0	10.0	0.047
4 : (15°<θ<20°)	2.25	96	100.0	10.0	0.023	3.66	96	100.0	10.0	0.038
5 : (20°<θ<25°)	2.59	128	100.0	10.0	0.020	4.18	128	100.0	10.0	0.033
6 : (25°<θ<30°)	2.76	158	100.0	10.0	0.017	4.28	158	100.0	10.0	0.027
7 : (30°<θ<35°)	2.78	188	100.0	10.0	0.015	4.07	188	100.0	10.0	0.022
8 : (35°<θ<40°)	2.66	216	100.0	10.0	0.012	3.85	216	100.0	10.0	0.018
9 : (40°<θ<45°)	2.46	242	100.0	10.0	0.010	3.47	242	100.0	10.0	0.014
10 : (45°<θ<50°)	2.21	266	100.0	10.0	0.008	3.24	266	100.0	10.0	0.012
11 : (50°<θ<55°)	1.93	288	100.0	10.0	0.007	2.63	288	100.0	10.0	0.009
12 : (55°<θ<60°)	1.67	308	100.0	10.0	0.005	2.20	308	100.0	10.0	0.007
13 : (60°<θ<77°)	3.97	1141	100.0	10.0	0.003	5.57	1141	100.0	10.0	0.005
14 : (77°<θ<94°)	2.16	1281	100.0	10.0	0.001	3.11	1281	100.0	10.0	0.002
15 : (94°<θ<111°)	1.18	1225	100.0	10.0	0.001	1.77	1225	100.0	10.0	0.001
16 : (111°<θ<128°)	0.66	1036	100.0	10.0	0.0006	0.96	1036	100.0	10.0	0.0009
17 : (128°<θ<145°)	0.37	756	100.0	10.0	0.0005	0.58	756	100.0	10.0	0.0007
Sum	32.85	7443				49.37	7443			